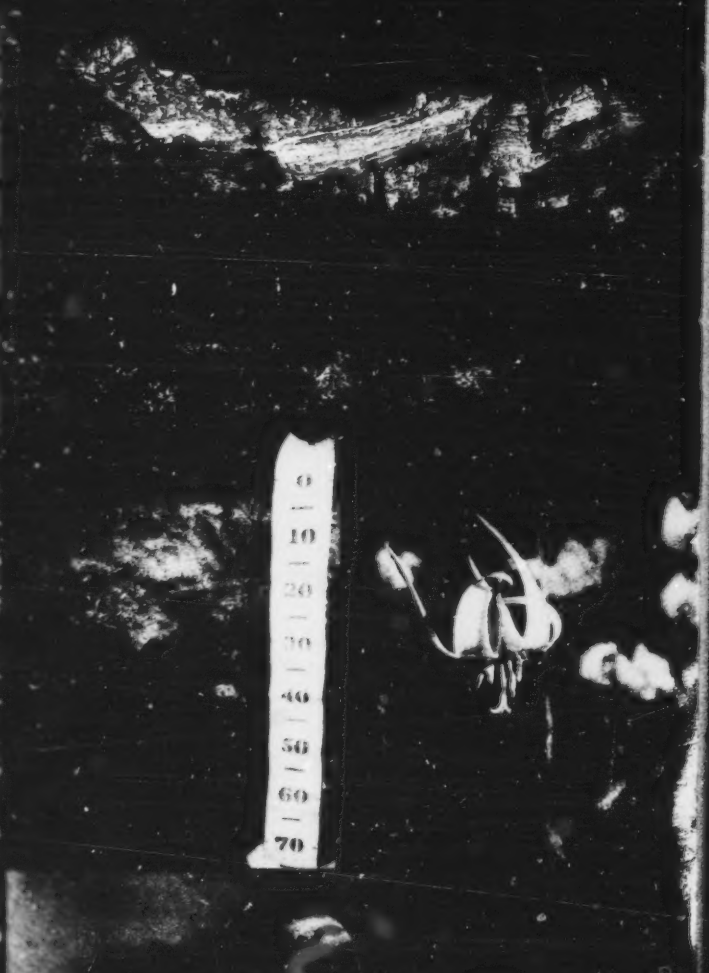
Ecological (Biophysical) Land Classification Of Banff and Jasper National Parks

Volume I: Summary

General Editors: W. D. Holland and G. M. Coen



Canada

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ABSTRACT

Banff and Jasper National Parks occupy about 17,520 km² (6765 mi²) in Canada's southern Rocky Mountains. The area extends from approximately 53° 30′ N and 119° 30′ W at the northwest corner of Jasper to about 50° 40′ N and 115° 20′ W at the southern extremity of Banff. It is bounded on the west by the Continental Divide. The Ecological (Biophysical) Land Classification of Banff and Jasper presents landform and soil, vegetation and wildlife information in a map and descriptive format at a scale of 1:50,000 using a legend that integrates the resource components in a holistic fashion. A three-level, hierarchical land classification system was developed using established landform and soil taxonomies, plus a classification of 85 vegetation types developed by the authors. The three levels are based on existing guidelines for Ecological (Biophysical) Land Classification in Canada and include, from highest to lowest level of generalization, Ecoregion, Ecosection, and Ecosite.

Ecoregion separations are based primarily on vegetation physiognomy and species composition which reflect macroclimate. Montane, Subalpine, and Alpine Ecoregions are recognized. The Subalpine Ecoregion is subdivided into Lower Subalpine and Upper Subalpine portions based on vegetational characteristics reflecting macroclimatic differences.

The Ecoregions are divided into 55 Ecosections. Ecosection separations are based on broad landform, drainage class, and soil differences. Landforms are comprised of ten genetic materials that have been divided into twenty genetic material units based on broad textural and chemical (calcareousness/reaction) differences.

The Ecosections are further separated into 124 Ecosites based on specific soil and vegetational differences that are considered insufficient, in magnitude or kind, to warrant separation at the Ecosection level. The Ecosites, plus eight Miscellaneous Landscapes, are the mapping units delineated on 1:50,000 maps. Wildlife information is presented at the Ecosite level. The importance of each Ecosite for most of the large and medium size mammals is described. Eighteen breeding bird associations and seven small mammal associations are defined using multivariate statistics. The association and its relative abundance are listed for each Ecosite. The landform, soil, vegetation, and wildlife of each Ecosite are briefly described in this volume.

PREFACE

Parks Canada requested assistance to meet a number of objectives of the National Parks Inventory Program. The request indicated a need for knowledge of the kinds and distribution of landforms, soils, vegetation, and wildlife. Such baseline information, plus the elucidation of some basic ecological relationships among these natural resource components, is primarily for resource management and land use planning within the National Parks.

Parks Canada initiated an Ecological (Biophysical) Land classification of Banff and Jasper National Parks (Fig. 1) in May 1974 as part of their resource inventory program. The objective was to provide an integrated landform, soil, vegetation, and wildlife inventory of the two parks at a scale of 1:50,000 with data presented in map and report format. The field work was completed in 1980.

The Ecological (Biophysical) Land Classification of Banff and Jasper studied the geomorphology, soils, vegetation, and wildlife of these two parks, exclusive of cultural features and land use patterns present as a result of development since 1885. Though aware of cultural features, land use patterns, and land use conflicts within the two parks, the inventory team followed the terms of reference established by Day et al. (1975). The concept of natural resource studies and their advantages and deficiencies were also described by McTaggart-Cowan (1977). However, most of the land in the parks is not intensively used. Byrne (1968), Scace (1968, 1970), and Nelson (1970) present much of the history and development that has affected Banff National Park. Further sources of information are contained in the three volume bibliography by Scace (1973).

The complete Banff-Jasper report consists of three volumes plus a map supplement and contains generalized and detailed descriptions of the landform, soil, vegetation, and wildlife resources.

Volume I is a summary account of landforms, soils, vegetation, and wildlife.

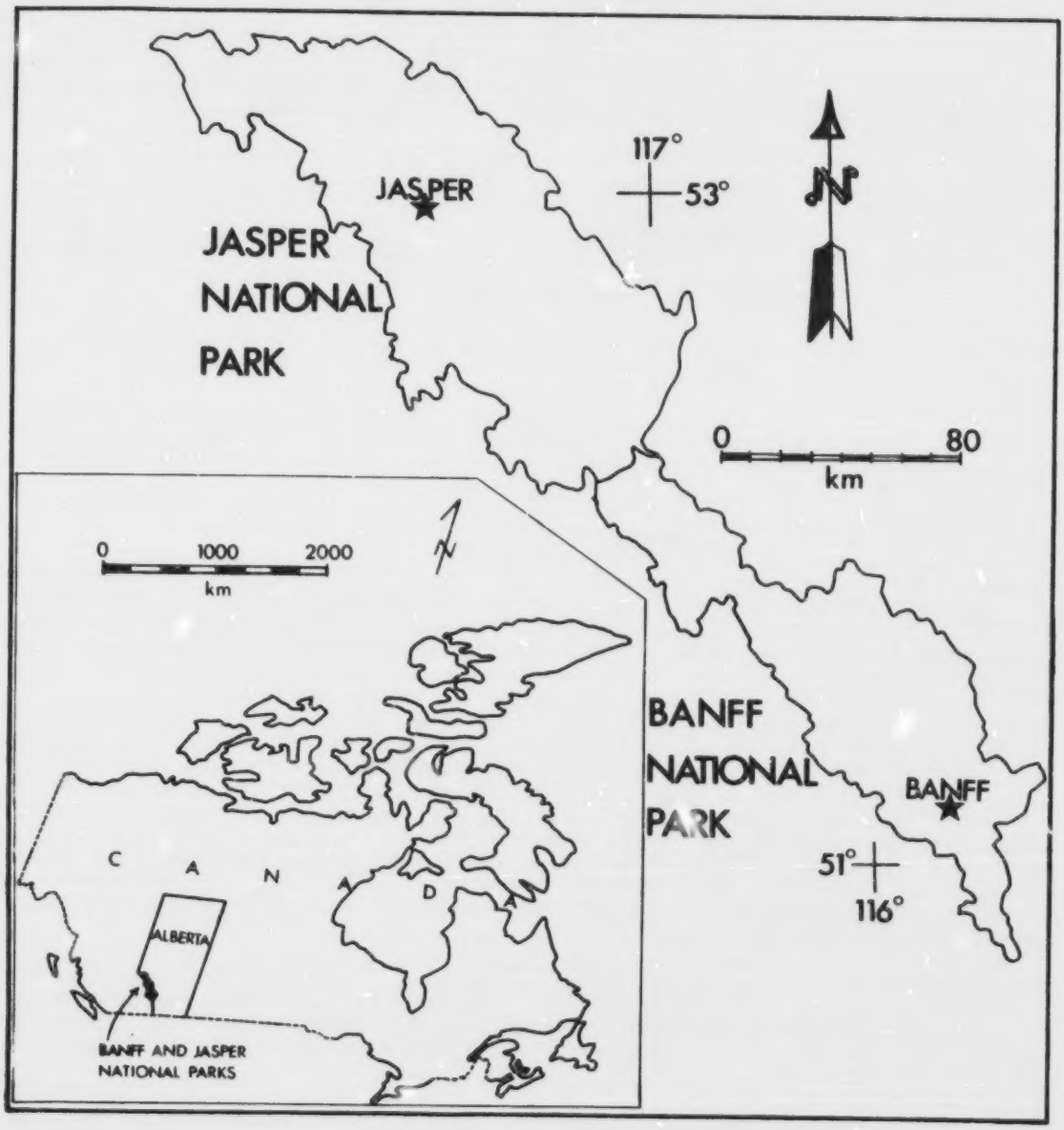
Chapter I of this volume contains the methodologies used both in the collection and processing of basic data andin the development of an integrated, holistic ecological land classfication system. Chapter II describes the study area in general. Chapter III provides Ecosection/Ecosite descriptions summarized from Volumes II and III and includes comments on management considerations. Chapter IV concerns resource use interpretation. It provides information on interpretive classification to help resource managers make land use suitability decisions.

Volume II contains a detailed account of the landforms, soils and vegetation. It describes the physical environment, including climate, physiography, topography, geology and geomorphology. The soil orders encountered and their distribution are also outlined. The vegetation information describes 85 vegetation types (v.t.s), a key to v.t. identification, an overview of community succession, special and significant species, and a checklist of vascular and nonvascular plants. The main body of Volume II provides an ecological integration of landforms, soils, and vegetation into three Ecoregions, 55 Ecosections and 124 Ecosites. An encyclopedic style was adopted to allow readers to consult the report on the subject of immediate interest without necessarily reading it from the beginning.

Volume III reports on the wildlife portion of the inventory. It contains a detailed discussion of the occurrence and abundance of each species of herptile, bird and mammal. Included are habitat preferences and notes on life history and management considerations specific to each species. The discussion of wildlife occurence on each Ecosite in Volume I is summarized from Volume III.

Other sections in Volume III describe breeding bird communities, small mammal associations, bird migration, ungulate range surveys, wildlife distribution by watershed, and various recommendations.

Fig. 1. Location of study area



The fourth part of the report is a map supplement, containing 24 maps (scale 1:50,000) and the Master Legend. The maps depict the distribution of Ecosites and Miscellaneous Landscapes. The Master Legend contains abbreviated information on the landform, soils, vegetation and wildlife of each Ecosite.

To obtain the most complete information, all report components should be used together. In addition, users should be aware that the information in this report is scale dependent. Site specific management decisions require site inspection and ground-truthing of the Ecosite data. Users may find it useful to consult with the authors regarding valid use of the information.

Copies of the original annotated air photos are filed with the Resources Studies Manager, Western Regional Office, Parks Canada, Calgary. Most basic data are stored in the Canada Soil Information System (CanSIS), Land Resource Research Institute, Ottawa.

CHAPTER I - METHODS

ECOLOGICAL (BIOPHYSICAL) LAND CLASSIFICATION METHODS..... W.S. Taylor, B.D. Walker and G.M. Coen.
METHODS OF SOIL DESCRIPTION AND ANALYSIS..... B.D. Walker
METHODS OF VEGETATION DESCRIPTION AND ANALYSIS..... P.L. Achuff
METHODS OF WILDLIFE DESCRIPTION AND ANALYSIS..... G.L. Holroyd and K.J. Van Tighem

ECOLOGICAL (BIOPHYSICAL) LAND CLASSIFICATION METHODS

PHILOSOPHICAL PRINCIPLES GOVERNING DEVELOPMENT OF THE ECOLOGICAL CLASSIFICATION METHODOLOGY

Experience has shown that for ease of use, all resource sectors should be linked to one set of map polygons of appropriate scale (1:50,000 was chosen for Banff-Jasper, Day et al. 1975) and the map legend should describe holistic, repeating ecological map unit concepts.

Three guidelines were used to develop the mapping procedure for Banff and Jasper:
1. Map, legend, and report should be easily interpretable.
2. Map unit concepts should be repetitive and holistic.
3. Map information should be uniform in reliability and intensity.

These guidelines were addressed by choosing a semi-closed legend and simple map symbol encompassing a holistic, ecological concept of landform, soils, and vegetation. Only the slope and, occasionally, selected landscape modifying processes were allowed to vary somewhat independently of the concept as applied to map polygons. This choice allowed the development of an ecological map unit concept (Jurdant et al. 1975, Rowe 1979), limited the number of concepts, permitted legend interpretation followed by mechanical labeling of repetitive map polygons, and included many factors in an easily remembered symbol. It also allows transfer of experience from a familiar area to an unfamiliar, but similarly labeled, area without reference to the many specific landscape components such as texture or lime.

Map delineations were chosen to correspond with recognizable landscape (usually landform) features because soil and vegetation often change where landforms change and reliable extrapolation from aerial photographs is possible. The smallest practical map polygon at scale 1:50,000 is 0.5 to 1 cm^2 and represents a tract of 25 to 40 ha (50 to 100 acres).

The legend in this study is hierarchical, but the mapping is not. That is, while initial landscape stratification established Ecoregion, Ecoregion subunit, and genetic material unit boundaries (Plates 82, 83, 84, Vol. II), in the final mapping polygons were named at the Ecosite level and modified by slope class. Thus, land is not cartographically stratified into polygons representing the Ecosection or Ecoregion however, therefore the aggregate that is Ecosection exists conceptually and therefore the legend is hierarchical.

MAPPING METHODOLOGY

METHODOLOGY OF LEGEND DEVELOPMENT

No nationally acceptable taxonomic system for ecological classification exists. There are useful guidelines (Lacate 1969, Jurdant et al. 1975, Wiken 1980) for developing classification

procedures. A vegetation "community type" taxonomy was developed for Banff and Jasper and combined with existing landform and soil taxonomies into a legend that defines the mapping units. This was accomplished through a series of annual legend, vegetation taxonomy, and mapping refinements following field checking of pretyped areas. Field teams consisted of one soil and one vegetation scientist, each recording information at a mutally acceptable, representative point on the landscape. Wildlife data collected the following season were also incorporated into this iterative process and resulted in further refinement of the Ecosite concept.

DESIGN OF THE MAPPING LEGEND

The mapping legend was developed with limits separating mapping concepts coincident with probable taxon limits where possible. The following discussion of Ecoregions, Ecosections, and Ecosites shows how these taxonomic levels influenced the mapping legend.

ECOREGIONS

Three Ecoregions are represented in Banff and Jasper: Montane, Subalpine, and Alpine. Separation was based on differences in vegetation physiognomy and species composition that reflect differences in macroclimate.

ECOSECTIONS

Ecoregions were divided into 55 Ecosections, based on broad genetic material and drainage class differences. These were named after geographic features and assigned a two letter, connotative symbol.

Genetic material classes that resulted in the establishment of Ecosections are listed in Table 1. These eight groupings were subdivided into two moisture regimes: *wet terrain* with soils classed as poorly drained and very poorly drained (C.S.S.C. 1978b) and *non-wet terrain* with soils classed as moderately well drained and drier. Imperfectly drained areas were variously considered wet or non-wet depending on their spatial and conceptual associates.

Wet terrain was not further subdivided. Non-wet terrain was subdivided on one or more of the following criteria where appropriate in occurrence, extent, or homogeneity:

1. Calcareous versus noncalcareous genetic materials.
2. Three genetic material textural groups, specifically coarse with >60% sand (sand, loamy sand, part of sandy loam), medium (loam, silt loam, part of sandy loam) and fine (clay loam, silty clay loam, silty clay textural classes). Textural classes are as defined by C.S.S.C. (1978a).
3. Soil-vegetation classes reflecting geomorphic activity or mesoclimate within a Genetic Material Unit (Table 8).
4. Landform surface expression producing a cartographically inseparable dry>wet landscape pattern.

Table 2 shows, as an example, organization of Lower Subalpine Ecosections associated with glacial genetic materials.

ECOSITES

The 55 Ecosections were further separated into 124 Ecosites on the basis of vegetation physiognomic and floristic differences as well as differences in soil parameters. They were named as numerical subdivisions of the Ecosection name. Subdivision into Ecosites was based on the following criteria where appropriate in occurrence, extent, or homogeneity:

1. Vegetation physiognomic groupings (closed forest, open forest, shrub, low shrub and herb, herb).
2. Habitat grouping (poplar forest, lodgepole pine forest, lodgepole pine/buffaloberry forest, Engelmann spruce-subalpine fir forest, a mosaic near timberline of heath tundra plus scattered Engelmann spruce-subalpine fir trees or krummholz, subalpine larch forest, avalanche complex vegetation).
3. Genetically similar soil or landform parameters (imperfectly drained soils, moderately

Table 1. Organization of Ecosections by Ecoregion and genetic material classes.

Genetic Material	Ecoregions and Subdivisions			
	Montane	Subalpine		Alpine
		Lower	Upper	
Residual	-	BZ	CP	HE
Landslide	GA	IB	BP	-
Colluvial	-	FV, SB	EN, WH, WF	BS, RD, TK
Glacial (morainal plus ice contact stratified)	PT, NY	BK, BY, CA, CV*, GT, ML, PR, (TZ)‡, WW †	AZ, EG, LV, PL, SF, SX*, TR	EF, JN, MP
Glaciofluvial	AT	BV, (TZ)	NG	-
Fluvial (including fluviolacustrine)	FR, HD, VL*	AL, HC*, PP, VD	CN, MQ, NT*	KA
Glaciolacustrine	NH*, RK	MC*, SP	-	-
Eolian	DV, TA	-	-	-

* Dominantly wet terrain

† Refer to Table 2

‡ The TZ Ecosection is defined as being associated with two genetic material classes

well drained and drier soils, or Brunisolic soils, Brunisolic–Regosolic soils, and Brunisolic–Podzolic soils, or ice contact stratified material and morainal material).

4. Complex Map Units (cartographically inseparable soil and vegetation patterns controlled by northerly and southerly aspect, dry and wet terrain, varying soil parent material depths over bedrock).

Table 3 gives an example of the subdivision of an Ecosection into its component Ecosites.

METHODS OF SOIL DESCRIPTION AND ANALYSIS

Pedon and site information as suggested by Day et al. (1975) was recorded on computer coding forms using the procedures and guidelines of Dumanski et al. (1975) and C.S.S.C. (1978 a,b). The soil, site, and vegetation data were sorted and organized by computer as an aid to developing and refining the mapping legend.

FIELD EXAMINATION AND SOIL DESCRIPTION METHODS

Ground checking was carried out after initial landscape stratification on aerial photographs to refine polygon boundary locations and to corroborate interpretation of landform, soil, and vegetation. Observation sites were located and annotated on the aerial photographs. Various pedons were chosen to represent soils of each Ecosite after ground checking and mapping procedures were completed. These pedons were described in detail on CanSIS forms and sampled for routine laboratory analysis.

Table 2. Example of Ecosection separations with glacial genetic materials (refer to Table 13) in the Lower Subalpine Ecoregion.

Glacial Genetic Materials of the Lower Subalpine								
Dominantly Wet Terrain	**Dominantly Non-wet Terrain**							
	Noncalcareous			**Calcareous**				
	Medium Texture	**Coarse Texture**		**Dominantly Medium Texture**				
		Morainal	Ice contact stratified	Regosolic herb	Brunisolic-Regosolic pine or grassland-pine	Brunisolic-Luvisolic pine	Brunisolic-Podzolic spruce-fir	Dry > wet pattern
CV	CA	ML	(TZ)*	WW	GT	PR+	BY	BK

* Subdominant genetic material is noncalcareous, coarse textured glaciofluvial

\+ Refer to Table 3

Table 3. Example of Ecosite separations within an Ecosection.

Ecosite	Landform*	Soils	Vegetation†
PR1	Till C blankets overlying inclined bedrock	Eutric Brunisols > Gray Luvisols	lodgepole pine false azalea, lodgepole pine feathermoss, lodgepole pine Labrador tea
PR2	Till C blankets overlying inclined bedrock	Eutric Brunisols > Gray Luvisols	logepole pine buffaloberry
PR3	Till C blankets overlying inclined or hummocky bedrock, hummocky Till C	gleyed Eutric Brunisols > gleyed Gray Luvisols	lodgepole pine forest
PR4	inclined Till C and Ice Contact Stratified Drift B	Northerly aspects: Eutric Brunisols Southerly aspects: Eutric Brunisols > Gray Luvisols, Regosols	Northerly aspects: Engelmann spruce - subalpine fir forest Southerly aspects: logepole pine forest
PR6	Ice Contact Stratified Drift B blankets overlying inclined or hummocky bedrock, hummocky Ice Contact Stratified Drift B	Eutric Brunisols > Gray Luvisols	lodgepole pine forest

* **Landform** Specific genetic material units are presented, refer to Geomorphology section, and Table 6

† **Vegetation** In order to differentiate PR1 from PR2, vegetation is presented at a more detailed level of description than for the other PR Ecosites.

CHEMICAL AND PHYSICAL ANALYTICAL METHODS

LABORATORY ANALYSIS

Chemical and physical analyses were carried out after the samples were air dried and ground according to the routine procedures used by the Alberta Institute of Pedology (C.S.S.C. 1978c). These involved a determination of:

Soil Reaction: pH was determined with a pH meter using a 2:1 0.01 M $CaCl_2$ solution to soil ratio (Peech 1965).[3.11][1]

Total Nitrogen: determined by the macro Kjeldahl–Wilforth–Gunning method (A.O.A.C. 1955). A mixture of HgO, $CuSO_4$, and K_2SO_4 (Kelpak) was used as a catalyst.

Calcium Carbonate Equivalent: inorganic carbon manometric method of Bascombe (1961).

Organic Carbon: by difference between total carbon and inorganic carbon. Total carbon was determined by dry combustion using an induction furnace (Allison et al. 1965) with a gasimetric detection of evolved CO_2 (Leco model 577–100). [3.611]

Cation Exchange Capacity: by displacement of ammonium with sodium chloride (Chapman 1965) except that an ammonium ion electrode was used to detect the displaced ammonium ion. [3.321]

Exchangeable Cations: extraction by Neutral N NH_4OAC (A.O.A.C 1955) with K, Mg, Na, and Ca determined by atomic absorption spectroscopy. [3.53, 3.531]

Sodium Pyrophosphate Extractable Iron and Aluminum: by McKeague (1967) method. The determination of Fe and Al was done by atomic absorption spectroscopy. [3.53,3.531]

Particle Size Distribution: by the pipette method of Kilmer and Alexander (1949) as modified by Toogood and Peters (1953), except that carbonates were not removed prior to dispersion.

Liquid Limit, Plastic Limit, and Plasticity Index: by the method outlined by ASTM (1970). [2.61, 2.62, 2.63]

One-third and Fifteen Bar Moisture: by the pressure plate and pressure membrane methods (U.S. Salinity Laboratory Staff 1954). [2.44]

Bulk Density: by the soil clod method using Saran (C.S.S.C. 1978c) The samples were oven dried and weighed. Calculations were based on air dry volume. Values reported are the arithmetic mean of 3 to 5 determinations per horizon. [2.221]

FIELD TESTS

Percolation: by the method suggested by the Alberta Department of Manpower and Labour (1972). This consists of digging a hole to the depth of interest followed by saturation for 24 hours before measuring the rate of drop of the water level in the hole.

Infiltration: by the double ring method with a constant head apparatus as suggested by Adams et al. (1957).

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[1]The numbers in [] indicate the method in C.S.S.C. (1978c).

METHODS OF VEGETATION DESCRIPTION AND ANALYSIS

FIELD SAMPLING

Since a prime objective of the vegetation study was to provide information for the Ecological Land Classification, the methods were subject to the constraints of a 1:50,000 mapping program. Polygons of homogeneous composition were initially outlined on air photos. Single sample plots were then established in homogeneous areas representative of the predominant vegetation of selected polygons. Plots were generally 20 x 20 m in forested vegetation, 15 x 15 m in shrubby vegetation and 10 x 10 m in herbaceous and dwarf shrub vegetation. Smaller plots (5 x 5 m or 1 x 1 m) were sometimes necessary to keep plot boundaries within a homogeneous area, as in some intricately patterned Alpine areas.

Within each plot, canopy cover was estimated to the nearest percent both for individual species and for each layer. Epiphyte cover was not estimated; species were merely noted as being present. Five layers were recognized: 1) Tree layer: woody plants >5 m tall, 2) Tall Shrub layer: woody plants 2 to 5 m tall, 3) Low Shrub layer: woody plants 0.5 to 2 m tall, 4) Herb-Dwarf Shrub layer: woody plants <0.5 m tall and all herbs regardless of height, and 5) Bryoid layer: terrestrial lichens and bryophytes. Cover values were also estimated for ground litter, rocks and stones, mineral soil, deadfall, and water. Usually, one of the largest trees in the plot was measured for height and diameter at breast height (dbh) and cored to determine its age. Average tree canopy height and the mean and range of dbh were also estimated.

Physical environmental factors noted included: elevation, slope, aspect, topographic position, relief shape, landform, soil subgroup and drainage class. Each plot was also rated on a moisture regime scale (Table 4).

Table 4. Ecological moisture regime classes (Walmsley et al. 1980).

Class	Usual Soil Drainage
xeric - very dry, little precipitation or high evapotranspiration, very low available water storage capacity (AWSC)	very rapid
subxeric - dry, low AWSC	rapid
mesic - moist, intermediate to high AWSC	well to moderately well
subhygric - moist to wet, variable AWSC, seasonal seepage	imperfect
hygric - wet, variable AWSC, permanent seepage	poor
subhydric - wet, variable AWSC, excess water most of time	very poor
hydric - very wet, standing water constantly	

VEGETATION CLASSIFICATION

The vegetation was initially classified into five physiognomic classes: Closed Forest (C), Open Forest (O), Shrub (S), Low Shrub–Herb (L), and Herb–Dwarf Shrub (H). In Closed Forests, the distance between tree crowns is no more than twice the mean crown diameter. This generally corresponds to a lower tree cover limit of 15 to 20%. In Open Forests, the distance between crowns is 2X to 5X the mean crown diameter and tree cover is generally between 5% and 15 to 20%. Vegetation with <5% tree cover was not considered forested. Within these physiognomic classes the classification was based primarily on the dominant species in each layer and on characteristic combinations of species. Dominance or importance was determined by cover values and thus, the classification has a quantitative basis. The plots were grouped on the basis of shared characteristics into abstract units called vegetation types (v.t.s). The v.t. is of the same order of magnitude as the "association" of the Zurich–Montpellier approach (Westhoff and van der Maarel 1973) or the "biogeocoenose" of Sukachev (Sukachev and Dylis 1964), although the bases and methods of recognition differ. Both seral and climax v.t.s were recognized. The species used to name the v.t.s were usually layer dominants. A hyphen (–) separates species in the same layer; a virgule (/) separates layers.

METHODS OF WILDLIFE DESCRIPTION AND ANALYSIS

SAMPLING RATIONALE

A wide variety of methods was chosen to collect data on the seasonal abundance, distribution and habitat characteristics of all species of mammals, birds, amphibians and reptiles that occur in Banff and Jasper National Parks. The broad scope of the inventory and the large area necessitated a variety of approaches to data collection. The sampling methods were fast, simple and quantitative. Some methods were directed specifically at relating wildlife abundance to the ecological land classification and these are described here. Other methods were used to survey the seasonal movements of selected species, to determine the densities of some species, and to locate less common wildlife species. These methods are detailed in Volume III.

Four methods were used to relate wildlife occurrence to each Ecosite. The main considerations in selecting these methods were:

1. Each sample area must be small enough to fit entirely within one map polygon. The maximum area sampled was 500 m x 500 m.
2. Each method must require minimal time, effort or equipment and allow a limited number of staff to sample a large number of sites over a wide area of rugged terrain.
3. Each method must be quantitative and easily taught to new staff.

The techniques selected were pellet group counts with forage use plots, track count transects, call count transects and snap traplines.

DESCRIPTION OF METHODS

Breeding bird populations were sampled by counting birds along 500 m transects before 9:00 a.m. between June 1 and July 15. The number of birds recorded was corrected for detectibility (Emlen 1971) and density indices were calculated for all transects on each Ecosite. Cluster analyses were used to identify bird communities which were then related to each Ecosite. Red squirrel numbers were also assessed using this method.

The relative abundance of small mammals on each Ecosite was determined using traplines of 100 *Woodstream Museum Special* traps baited for two nights. The number of rodents and shrews that were caught was averaged for each Ecosite. The averages were used in a cluster analysis to identify associations of small mammals.

The relative importance of each Ecosite to each ungulate species was determined by counting pellet groups. Each count was conducted over 25 quadrats (2 m x 5 m) spaced 50 m apart in 5 rows of 5 quadrats each. The number of pellet groups of each species was multiplied by 40 to

give the number of pellet groups per km² and the average density was calculated for each Ecosite and vegetation type. The number of snowshoe hare pellets was counted in each corner 0.5 m x 0.5 m of each quadrat. These counts were multiplied by 400 to yield the density of hare pellets per km². On some pellet group sample sites the vegetation was also surveyed. At these sites, the abundance of the six most common plants was noted in each quadrat and use of any plants was recorded as a percentage of the plants eaten. The results were tallied for all quadrats on each Ecosite and vegetation type. This information was used to identify major forage plants on each Ecosite and to partially explain the importance of an Ecosite to ungulates.

Winter mammal activity was assessed by counting the number of tracks intercepted by a straight transect of 0.5 km or longer. Track counts were standardized to the mean number of tracks per 10km-day by dividing the total track count by the total distance of the transects and the number of days since the last snowfall. These figures were averaged for each Ecosite and vegetation type. Snow depth measurements were made on most transects. In addition, all birds seen or heard were recorded.

ECOLOGICAL INTEGRATION ANALYSIS

The above four methods were the primary sampling techniques for relating the abundance of wildlife to each Ecosite and vegetation type. The numerical values derived from each method are not presented here. Instead, the values were ranked in numerical order and rated as follows: the lowest third were rated as Low, the second third as Medium, the top third as High, and the top 5-8% as Very High. These ratings were then assigned to the corresponding Ecosites. Separate ratings were derived for each carnivore and ungulate species, since the range of values for each species varied greatly depending on the species' abundance and the degree to which it occurred in groups. For small mammals and breeding birds, rating schemes were developed for species groups. This was because of the large number of species involved and the lack of species-specific management in the national parks.

Thus, for each species or species group, the importance of an Ecosite is considered to be directly comparable to the measured relative abundance of that species on an Ecosite. Critical habitats are the highly and very highly ranked Ecosites and vegetation types, in addition to habitats with special functions (e.g. denning, calving or staging). It is important to note that some critical areas may be site-specific and not predictable by habitat designation. Thus, random observations and site visits should be included in any site-specific analysis of wildlife.

An additional method of ranking Ecosites was devised for lynx, coyotes, wolves and cougars since relatively few tracks of these species were recorded. From other studies of their food habits, a ranking scheme was created based on the importance of each Ecosite to their prey species weighted by the proportion of the prey in each predator's diet. For further details see Volume III.

In this volume the importance of each Ecosite to wildlife is briefly discussed. Generally, only the species for which the Ecosite is highly or very highly important are identified. Factors that result in the importance rating, such as snow depth, forage abundance and prey availability are discussed briefly. In addition, for ungulates and carnivores, a single rating of importance is presented for each Ecosite. This rating is derived from the sum of the individual species ratings. It is not intended to be used for site specific planning or management but for planning at the park level or larger.

CHAPTER II - DESCRIPTION OF THE STUDY AREA

LOCATION AND PHYSIOGRAPHY ..... W.S. Taylor and D.T. Allan
CLIMATE ..... B.D. Walker and W.D. Holland
GEOLOGY ..... W.S. Taylor
GEOMORPHOLOGY ..... B.D. Walker
SOILS ..... B.D. Walker, W.D. Holland and G.M. Coen
VEGETATION ..... P.L. Achuff and I.G.W. Corns
WILDLIFE ..... G.L. Holroyd and K.J. Van Tighem

LOCATION AND PHYSIOGRAPHY

INTRODUCTION

Banff and Jasper are situated within the Continental Ranges of the Southern Rocky Mountains, part of the Eastern System of the Cordilleran region of Canada (Bostock 1970). The parks form a crude northwest-southeast trending parallelogram that extends 425 km from about 53°30' N and 119°30' W to 50°40' N and 115°20' W. The approximate area of Jasper is 10,880 km², while Banff is 6,640 km².

Physiographic features of Banff and Jasper are strongly controlled by structure of the Front and Main Ranges geologic subprovinces. Both they and their features trend in the same direction mentioned above. The Front Ranges typically have steeply dipping strata that produce linear ridges of resistant rock separated by subparallel valleys carved from softer rock. Bedrock dips steeply southwest, providing long, smooth slopes on this aspect and precipitous cliffs on northeast aspects. The Main Ranges strata, for the most part gently dipping, produce nonlinear ranges with high individual or clustered peaks capped by resistant rock.

Peak elevations generally increase from east to west and are highest in the vicinity of the Columbia Icefield, reaching over 3700 meters. The lowest elevation, 990 meters, occurs where the Athabasca River exits Jasper.

DRAINAGE AND HYDROLOGY

Banff and Jasper abut the Continental Divide and are part of the headwaters for the Peace, Athabasca, and Saskatchewan River Systems. The mountains comprise about one-eighth of the drainage area but supply about seven-eighths of the total annual flow of the Saskatchewan River System. In the parks, approximately 50 percent of mean annual precipitation contributes to mean annual runoff, and about 70 percent of total annual flow occurs from June through August (Hanson n.d.) Flooding potential from rapid snow melt or a heavy storm is greatest during this period.

Stream gradients vary from 80 m/km or more in steep terrain to 0.13 m/km for the Bow River just above Banff townsite. Stream courses and gradients are strongly controlled by topography.

Lakes are also controlled by topography, though Lake Minnewanka, the largest lake in Banff, was created for hydroelectric power production. Other lakes are dammed by natural means (e.g. landslides, moraines, fans) or are in natural depressions such as kettles. Where accessible, they are important for recreation.

Subsurface flow is important, especially in areas of limestone, such as the spectacular example of karst between Medicine Lake and Maligne Canyon in Jasper (Brown 1973). Hot springs occur in both Banff and Jasper, and discovery of the Cave and Basin near Banff townsite in 1883 led to the creation of Canada's first National Park.

SURFACE EXPRESSION

Main physiographic features of Banff and Jasper may be traced to mountain building processes and subsequent erosion, with the Pleistocene glaciation a significant event. Vestiges of this glaciation and the processes involved are still active in the glaciers and icefields at high elevations that chiefly occur near the Continental Divide. Both glacial and postglacial surface features are described in the geomorphology section the Ecosite descriptions, and the legends.

PHYSIOGRAPHY AND PEOPLE

Physiography affects land use in the parks in many ways. Self-evident relationships include:

1. amenable topography and climate that make the Montane Ecoregion subject to the most intense land use in the parks
2. the passes providing transportation and utility corridors with attendant land use pressures
3. the combined influence of structure and glaciation that results in aesthetic lakes in cirques on the eastern sides of individual ranges, thus attracting development.

CLIMATE

OVERVIEW

Climatic data for Banff and Jasper National Parks are scarce. Janz and Storr (1977) provide the most comprehensive climatic overview for the contiguous National Parks within the Canadian Rocky Mountains.

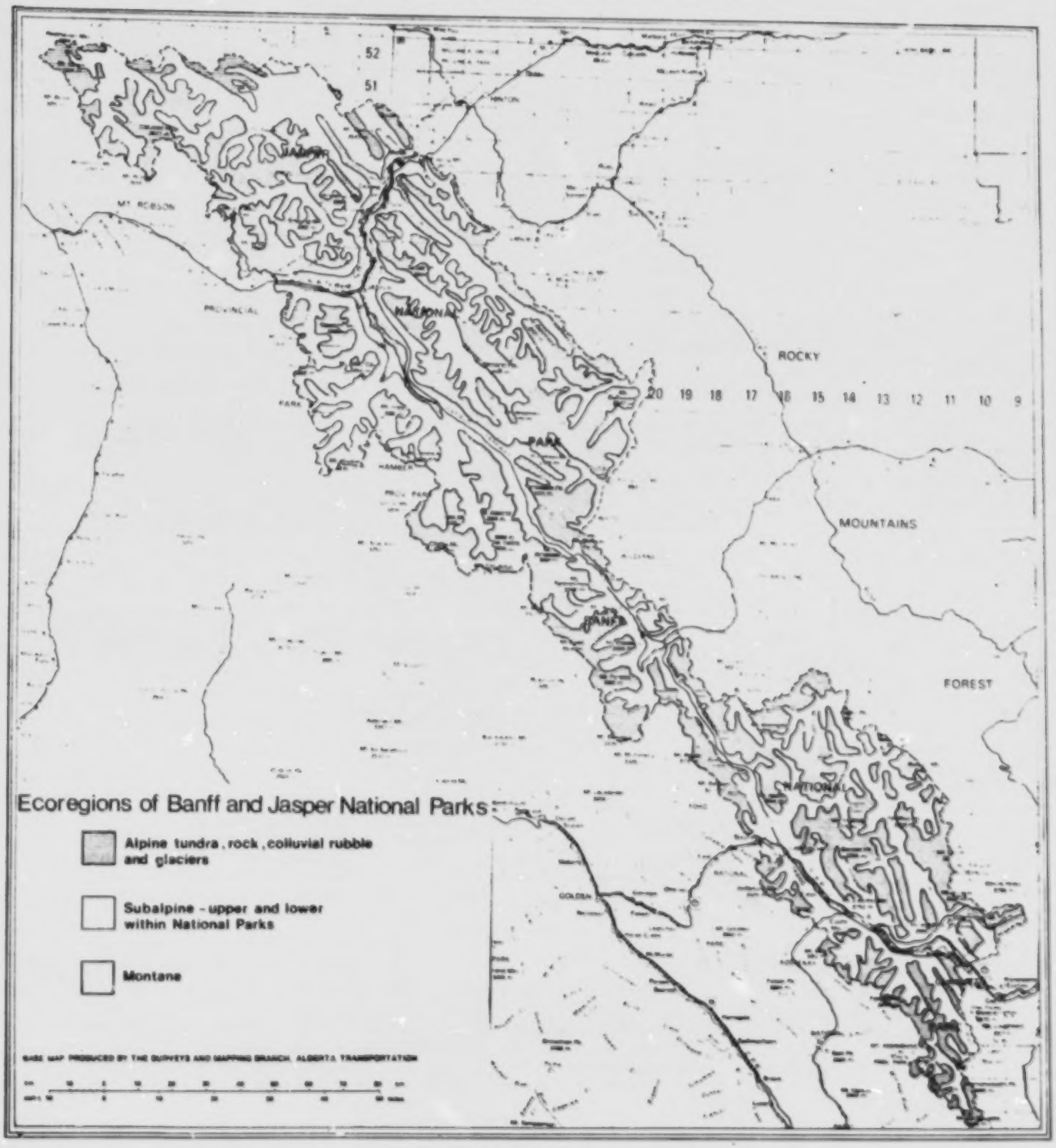
The macroclimate of Banff and Jasper is continental with long winters which can be cold and short summers that are cool with occasional hot spells. According to Koeppen's climatic classification (Trewartha 1957) most valley floors and lower slopes have a Dfc climate (Cold Snowy Forest Climate with no distinct dry season; cool short summers).

Both parks are subject to the same air masses and weather systems that migrate across western Canada at mid-latitudes. However, the mountain topography modifies macroclimate creating mesoclimatic and microclimatic gradients. The predominant northwest-southeast orientation of mountain ranges and valleys is nearly perpendicular to the prevailing winds aloft and influences precipitation distribution, winds, and the intrusion of Arctic air from the prairies to the east. Topography, especially aspect and elevation, causes climatic variation over short distances.

CLIMATE AND ECOREGIONS

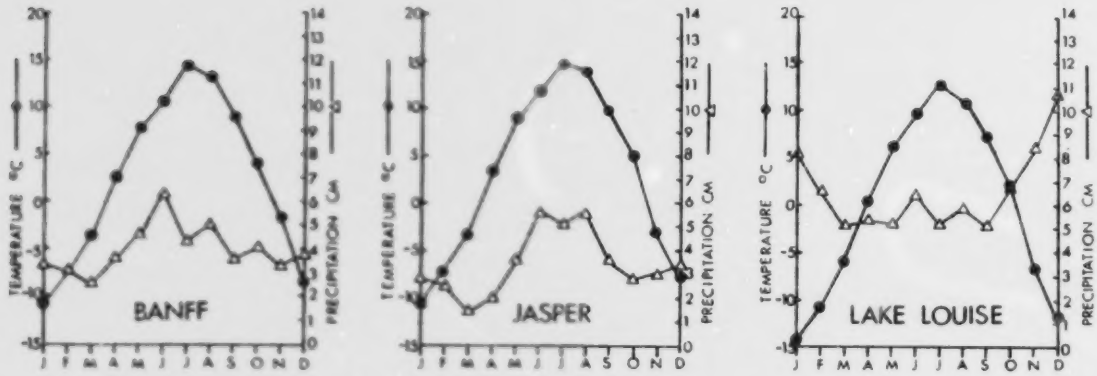
Lack of sufficient climatic data makes it impossible to classify Banff and Jasper, at scales of 1:250,000 and larger, using climatic data solely. However, vegetation, as a biotic component of an ecosystem, reflects climate. Thus, vegetation differences at a high level of generalization have been used to indicate climatic units. Based primarily on vegetation physiognomy and composition, four units have been delineated: Montane Ecoregion, Subalpine Ecoregion with Lower Subalpine and Upper Subalpine subunits, and Alpine Ecoregion. An approximation of their distribution is shown in Fig. 2.

Fig. 2. Ecoregions of Banff and Jasper National Parks



The most complete climatic data are available for the Montane Ecoregion. Fig. 3 illustrates temperature and precipitation data for Banff and Jasper townsites, both located in the Montane, and Village Lake Louise, located in the Lower Subalpine.

Fig. 3. Mean monthly temperature and precipitation for Banff and Jasper townsites and Village Lake Louise.



THE MONTANE ECOREGION

The climate of the Montane Ecoregion is the warmest and driest in the two parks. Mean yearly temperature is 2° to 3° C, based on Banff and Jasper townsite data. Average annual precipitation is about 465 mm (Tables 5 and 6) with summer precipitation being slightly greater than winter precipitation (Fig. 3).

Although the Montane is generally the warmest Ecoregion, it probably has the greatest temperature fluctuation. Extreme minimum temperatures in the range of −50° to −54° C (such low temperatures are rare) have been experienced in the main valleys below 1500 m (Janz and Storr 1977). These are related to temperature inversions with little mixing by wind and invasion of cold Arctic air from the north. Extreme maxima are of the order of 38° C in valleys below 1200 m but temperatures above 32° C are relatively rare (Janz and Storr 1977). Frequency of summer frost in the Montane is low and also indicates relatively mild climate.

Winds in the Montane are slightly stronger and more frequent than in other areas because valleys mapped as Montane are oriented approximately parallel to the prevailing westerlies aloft. Warm winter winds (chinooks) from Pacific air masses raise winter temperatures and the Montane Ecoregion is intermittently snowfree.

THE SUBALPINE ECOREGION

The Subalpine Ecoregion occurs at elevations above the Montane Ecoregion and is cooler and moister. The mean yearly temperature is about 0° C at low elevations, based on the Village Lake Louise data, and decreases with increasing elevation (i.e. about 0.5° C/100 m; summer lapse rate). Precipitation increases with elevation and the average annual precipitation of the Upper Subalpine (763 mm) is greater than the Lower Subalpine (665 mm), based on data from a few stations (Tables 5 and 6). Winter precipitation is greater than summer precipitation (Fig. 3) and the

Table 5. Average annual preciptation, October 1966 to September 1980, for stations in Banff National Park.

Station	Type of Gauge [a]	Elevation (m)	Latitude	Longitude	No. Years Observation	Precipitation Avg./Yr. (mm)	Ecoregion
Banff	1	1397	51° 11′	115° 34′	14 $\bar{X}$=	455 455	Montane
Howse R. Cabin	2	1494	52° 03′	116° 47′	10	492	Lower Subalpine
Alexandra R. Cabin	2	1494	52° 03′	117° 07′	10	582	
Lake Louise	1	1533	51° 25′	116° 10′	14	569	
Brewster Ck. (headwaters)	2	1575	51° 08′	115° 41′	9	747	
Cascade Lem	2	1646	51° 20′	115° 35′	6	490	
Waterfowl Lake	2	1793	51° 51′	116° 38′	10	711	
Sarbach L.O.	2	1829	51° 55′	116° 45′	13	719	
Temple Lodge	2	1890	51° 26′	116° 09′	14 $\bar{X}$=	667 662	
Bow Summit	2	2070	51° 43′	116° 27′	14	728	Upper Subalpine
Alexandra L.O.	2	2043	52° 06′	116° 55′	10	773	
Fatigue	2	2143	51° 01′	115° 40′	9	875	
Snowflake I.J.P.	2	2210	51° 38′	115° 50′	6	523	
Sunwapta (Nigel Ck.)	2	2256	52° 12′	117° 07′	14 $\bar{X}$=	814 742.6	

a Type of Gauge

1 Daily
2 Sacramento Storage Gauge (usually recorded twice a year)

Table 6. Average annual precipitation, October 1966 to September 1980, for stations in Jasper National Park.

Station	Type of Gauge [a]	Elevation (m)	Latitude	Longitude	No. Years Observation	Precipitation Avg./ Yr. (mm)	Ecoregion
Jasper East Gate	1	1003	53° 14′	117° 49′	14	619	Montane
Warden Station (U. of A.)	2	1024	52° 48′	118° 08′	6	361	
Jasper (townsite)	1	1061	52° 53′	118° 04′	14	383	
Jasper West Gate	1	1127	52° 52′	118° 23′	5	571	
Athabasca Falls	1	1181	52° 40′	117° 53′	6	421	
						$\bar{X}$=471	
Miette Hot Springs	1	1341	53° 08′	117° 46′	6	827	Lower Subalpine
	2	1341	53° 08′	117° 46′	10	684	
Willow Creek	2	1402	53° 23′	118° 21′	8	422	
Smoky River Warden	2	1463	53° 22′	119° 16′	9	701	
Sunwapta Warden	1,2	1554	52° 27′	117° 27′	9	797	
Signal 4	2	1677	52° 53′	117° 59′	6	586	
Pyramid 4	2	1677	52° 58′	118° 07′	6	801	
Athabasca Pass	2	1745	52° 23′	118° 11′	4	1561*	
Topaz Lake	2	1758	53° 23′	118° 48′	8	524	
Brazeau Warden	2	1768	52° 24′	117° 01′	9	438	
Rocky Forks	2	1840	52° 50′	117° 24′	8	622	
Maligne Lake	2	1845	52° 44′	117° 38′	10	565	
						$\bar{X}$=710.7	
		*Excluding Athabasca Pass station $\bar{X}$ = 633.4					
Amethyst Lake	2	1966	52° 42′	118° 16′	8	974	Upper Subalpine
Columbia Icefields	1	1981	52° 41′	117° 10′	7	792	
Marmot Basin	2	1982	52° 47′	118° 07′	10	742	
Pyramid 5	2	2043	52° 58′	118° 07′	6	713	
Signal 2	2	2043	52° 52′	117° 59′	6	691	
						$\bar{X}$=782.4	
Pyramid Mountain	2	2767	52° 57′	118° 08′	10	595	Alpine

a Type of Gauge:

1 Daily
2 Sacramento Storage Gauge (usually recorded twice a year)

incidence of measurable summer snowfall is greater than in the Montane. Precipitation in eastern portions of the parks appears to be lower than in western regions. This trend is supported by the scattered occurrence of Cryosolic soils (Achuff and Coen 1980) and dry grassland and shrubland vegetation in eastern subalpine areas. Conversely, Janz and Storr (1977) describe the area from Athabasca Pass to Freshfield Icefield (the Icefields area) as having an abnormally high precipitation regime relative to other areas of the parks.

Temperature fluctuation is narrower in the Subalpine than in the Montane. Janz and Storr (1977) indicate that the occurence of extreme minima in the −48° to −54° C range is rare above 1500 m elevation. Extreme maximum temperatures are lower than in the Montane because of a decrease with elevation that is probably similar to the lapse rate of mean maximum temperature (i.e. about 0.7° − 0.8° C/ 100 m, Janz and Storr 1977). Data from Bow Pass (6 years record, Janz and Storr 1977) and Mt. White (2.5 years record) in Banff indicate extreme maxima of 28° to 29° C in the Upper Subalpine at 1850 to 1970 m elevation.

Winds are generally light in the Subalpine, although there is evidence of wide variation, related mostly to topography. Thus, winds are important in east−west trending valleys and passes that traverse the mountain ranges, and also at higher elevations as indicated by stunted and krummholz open forest, and on exposed nonforested localities such as grasslands.

THE ALPINE ECOREGION

The Alpine Ecoregion occurs at elevations above the Subalpine Ecoregion and is the coldest in Banff and Jasper. Cool mean temperature projections are based on the trends of temperatures at lower elevations. Likewise, the temperature range is narrower in the Alpine (Janz and Storr 1977). This trend also extends to extreme maxima and minima. Precipitation increases with altitude from the Montane Ecoregion upward into the Alpine, but somewhere in the Alpine the trend may reverse. The lack of forest vegetation demonstrates the rigorous climate of the Alpine Ecoregion.

Winds are important in the Alpine. Janz and Storr (1977) report that all areas above about 2300 m are windy but winds may be light for several days in succession, particularly in summer. Erodible, exposed surfaces are often deflated and snow is redistributed by wind. Complex vegetation patterns in the Alpine are often linked to varying topographic exposures and resultant snow depth variability.

GEOLOGY

INTRODUCTION

Banff and Jasper lie in the southern portion of the Rocky Mountain Thrust Belt, the southeasterly−most sector of Canada's Cordilleran Orogen. This orogen represents the present state of evolution of the Cordilleran Geosyncline. Regional setting and stratigraphic and structural frameworks are outlined by Douglas et al. (1970) and Price and Mountjoy (1970a).

STRATIGRAPHIC FRAMEWORK AND ECOLOGICAL LAND CLASSIFICATION

Three categories of bedrock in Banff and Jasper are significant to this Ecological Land Classification. These are:

1. noncalcareous, medium and coarse grained clastic
2. noncalcareous, medium and fine grained clastic
3. carbonate and calcareous clastic.

This grouping was chosen because of the influence of these lithologies on unsorted genetic materials (Table 7) The stratigraphic column and named Groups and Formations in which these

lithologies occur are shown in Fig. 4.

Table 7. Correlation of generalized bedrock lithology with calcareousness and textural groups of unsorted genetic materials.

Generalized Bedrock Lithology	Calcareousness and Texture of Unsorted Genetic Material
Noncalcareous, medium and coarse grained, clastic	Noncalcareous, coarse textured
Noncalcareous, medium and fine grained, clastic	Noncalcareous, medium textured
Carbonate and or calcareous clastic	Calcareous, medium textured

STRUCTURAL FRAMEWORK AND ECOLOGICAL LAND CLASSIFICATION

Orogeny and subsequent erosion has produced four northwest–southeast trending geological subprovinces in the Rocky Mountains, only two of which are well expressed in Banff and Jasper. Regional stratigraphy, structure, and topography distinguish these subprovinces, and distribution is shown in Fig. 5. Typical Foothills subprovince essentially does not occur in the parks. The Front Ranges subprovince is regionally represented by southwest dipping Devonian to Jurassic rocks arranged in subparallel ridges of resistant Paleozoic carbonate separated by valleys carved from recessive Mesozoic clastics. Regionally, Main Range beds are gently dipping and the mountain ranges are not linear. Typically, peaks are capped by pre–Devonian carbonates and grade downwards in time with decreasing elevation to clastics of the early miogeosyncline (Fig. 4).

Some Ecosites have a direct link to a specific geological setting. For instance, the source strata for an Ecosite mapped on noncalcareous, medium textured till located in the Main Ranges were probably of the Miette Group (Figs. 4, 5, Table 7). Distribution of certain Ecosites correlates closely with distribution of Groups and Formations as shown on maps prepared by the Geological Survey of Canada. Geological maps complementing this Ecological Land Classification are by Price and Mountjoy (1970a,b), (197la,b,), (1972a,b), Cook (1975), Price et al. (1978), Price et al. (1979), and Mountjoy (1980).

GEOMORPHOLOGY

INTRODUCTION

Soil and vegetation development is influenced by landform. Landform classes are defined in terms of genetic material, surface expression, and modifying processes (C.S.S.C. 1978b). Genetic materials are emphasized in this section and are classified, with some modifications to taxa definitions, according to the C.S.S.C. (1978b) landform classification system.

Genetic materials are organized into four groups: consolidated (bedrock), unconsolidated mineral, organic, and ice. The unconsolidated mineral group is subdivided according to mode of formation or deposition. Ten genetic material classes (modified from C.S.S.C 1978b) are recognized. These are listed in Table 4 in order of increasing source diversity, increasing influence of depositional agents, and decreasing influence of bedrock lithology.

Fig. 4. Generalized time scale and stratigraphic column for Banff and Jasper.

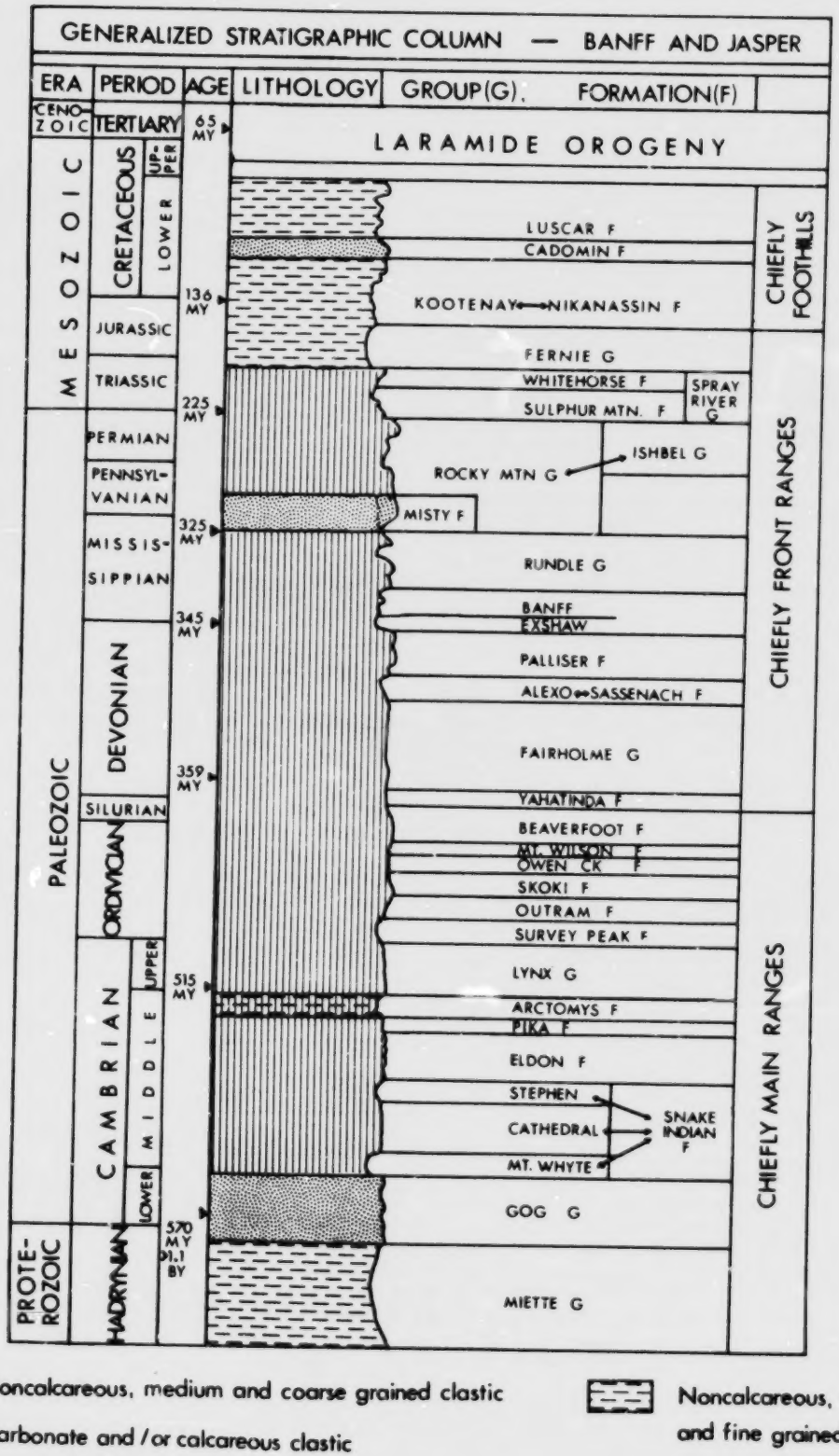
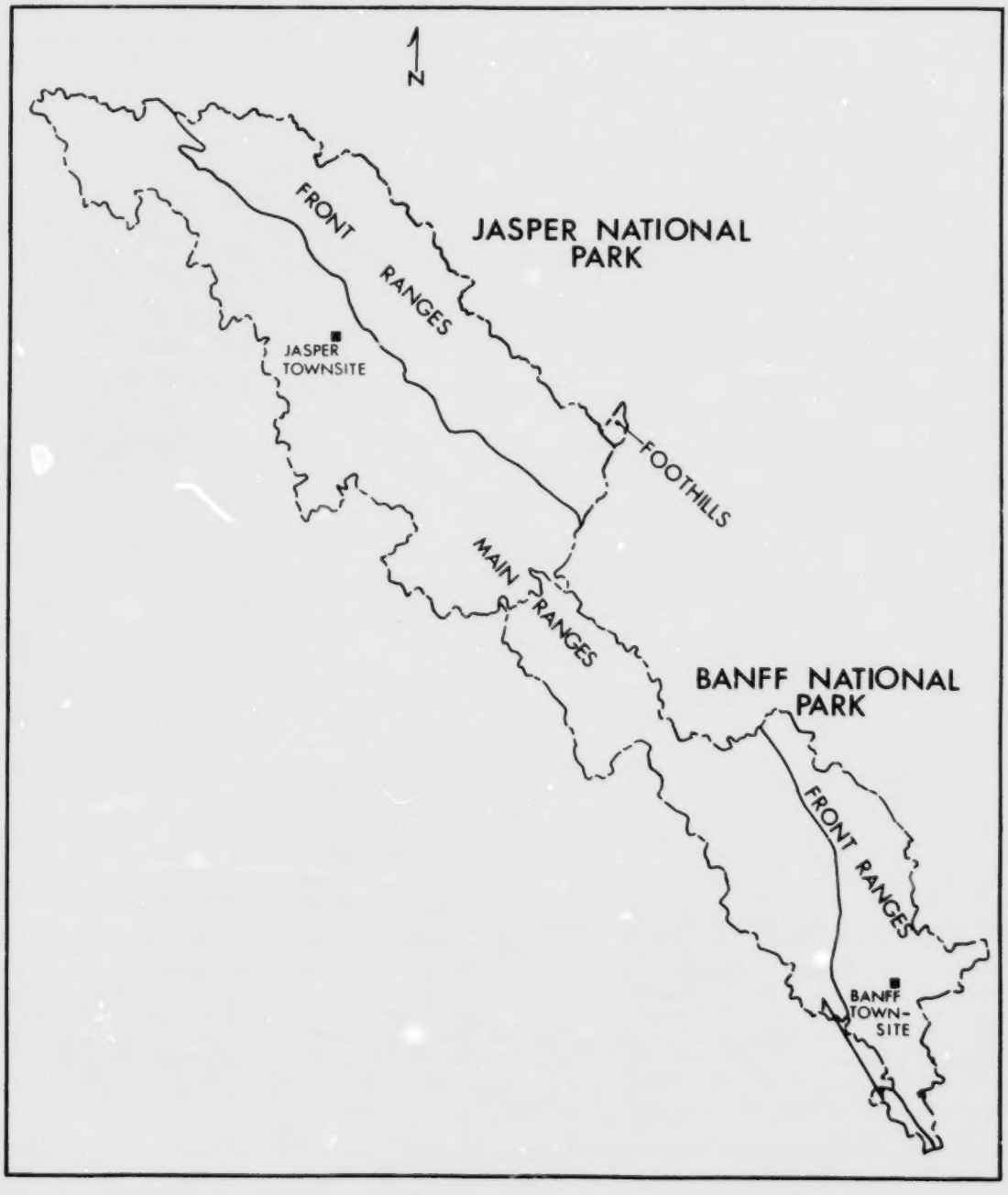


Fig. 5. Geologic subprovinces of Banff and Jasper.



Genetic material classes are further subdivided according to textural and chemical (calcareousness) properties imparted either by source area lithology or modified by depositional media. Twenty genetic material units, listed in Table 8, are defined specifically for the Banff–Jasper Ecological Land Classification.

Table 8. Characteristics of modal unconsolidated mineral genetic materials.

	Medium	Genetic Material Symbol*	Genetic Material Class†	Characteristics: Calcareousness	Characteristics: Texture	Genetic Material Unit
Genetic material derived from increasingly diverse bedrock lithology	Rock (*in situ* and failed)	R^{U*}	Residual	noncalcareous	medium	Residuum A
				calcareous	medium	Residuum B
		C^{A*}	Landslide	variable	variable	Landslide material
	Gravity	C	Colluvial	noncalcareous	coarse	Colluvium A
				noncalcareous	medium	Colluvium B
				calcareous	medium	Colluvium C
	Ice	M	Morainal	noncalcareous	coarse	Till A
				noncalcareous	medium	Till B
				calcareous	medium	Till C
		MI^{G*}	Ice Contact Stratified	noncalcareous	coarse	Ice Contact Stratified Drift A
				calcareous	variable	Ice Contact Stratified Drift B
	Flowing Water	I^{G}	Glaciofluvial	noncalcareous	coarse	Glaciofluvial material A
				calcareous	coarse	Glaciofluvial material B
		I	Fluvial	noncalcareous	coarse-stratified	Fluvial material A
				calcareous	coarse-stratified	Fluvial material B
	Still Water	I^{L*}	Fluviolacustrine	altered	fine-stratified	Fluviolacustrine material A
				calcareous	fine-stratified	Fluviolacustrine material B
		I^{G}	Glaciolacustrine	calcareous	fine	Glaciolacustrine material
	Air	I	Eolian	calcareous	medium	Eolian material A
				altered	medium	Eolian material B

Restricted bedrock source — Unsorted — Increasingly diverse sources — Increasingly sorted

* The abbreviations used to designate Genetic Materials are according to C.S.S.C. 1978b except for R^{U}, C^{A}, MI^{G}, and I^{G} which are defined in this section.

† Modified from C.S.S.C. (1978b).

RESIDUAL GENETIC MATERIAL

Residual material in Banff and Jasper is physically and chemically weathered bedrock and is designated by landform symbol R^{U}. It includes failed bedrock that retains some original bedding structure and is nonfragmental. Residual material is derived from recessive, medium and fine grained, clastic bedrock. It may be either noncalcareous or calcareous and is divided into two genetic material units (Residuum A and Residuum B) on that basis.

Residuum A is normally medium textured and noncalcareous (acidic), with dominant characteristics as presented in Table 9. It is the dominant residual material of the Main Ranges. Residuum B is normally medium textured and calcareous, hence neutral to moderately alkaline in reaction (Table 9). It is distributed primarily in the Front Ranges. Fine earth content decreases and coarse fragment content increases with depth in sola developed in both residual materials. Residuum A is defined as having sola with pH $\leq$ 5.5 to a depth of 25 cm below the top of the B horizon. Residuum B is associated with sola having pH > 5.5.

Surface expression of both residual materials is inclined, hummocky, or ridged depending on the nature of the underlying bedrock and whether or not slope failure has occurred. Slopes commonly range to 45%. Solifluction and cryoturbation are common modifying processes in the

Table 9. Characteristics of residual genetic material units.

Genetic Material Unit	Dominant Source	Usual Textural Properties		Usual Chemical Properties	
		Fine Earth	Coarse Fragments	Calcareousness	pH
Residuum A	Noncalcareous, medium to fine grained, clastic bedrock (e.g. Miette Group)	20-60% sand and 5-20% clay	50-90%	Noncalc.	4.5-6.0
Residuum B	Calcareous, medium to fine grained, clastic bedrock (e.g. Spray River Group)	20-60% sand and 5-20% clay	50-90%	<35% $CaCO_3$ equiv.	7.0-8.0

Alpine Ecoregion.

LANDSLIDE GENETIC MATERIAL

Landslide genetic material in Banff and Jasper is generated by rapid, gravity-induced movement of mineral material downslope en masse. It is designated by the landform symbol c^ and represents a subset of colluvial material as defined by C.S.S.C. (1978b). Landslides are sporadically distributed throughout the parks and consist of failed bedrock of various lithologies. Occasionally they originated from unconsolidated mineral material.

Coarse fragments comprise 50 to 100% of the material by volume and are rubbly (angular fragments <256 mm) and blocky (angular fragments >256 mm). Most landslides are fragmental at depth. Surfaces are often exceedingly to excessively stony. Fine earth textures vary from medium to coarse, spanning the silt loam, loam, sandy loam, and loamy sand textural classes defined by C.S.S.C. (1978a). Much of the fine earth fraction in soils on older slides is Eolian Material B. Soil and vegetation develop more rapidly on finer grained slides, while coarsest portions have sparse soil and vegetation regardless of age. Calcareousness ranges from non to extremely calcareous. Both extremes may occur within one slide derived from contrasting materials.

Surface expression of landslide material is hummocky, often superimposed on a rising, inclined slope. Hummocks are produced by the landslide process, while the overall incline reflects bedrock control at some depth. Other genetic materials, especially morainal material on valley walls and floors, many underlie landslides at variable depth.

COLLUVIAL GENETIC MATERIAL

Colluvial genetic material in Banff and Jasper is generated by the slow or rapid, gravity induced, downslope displacement of isolated mineral fragments. It is designated by the landform symbol c and represents a subset of colluvial material as defined by C.S.S.C (1978b). Soil creep and snow avalanching, with avalanche related fluvial activity including mudflows, are the processes responsible for colluvial material accumulation. This material is generally postglacial and mantles steep valley walls. Three colluvial genetic material units (Colluvium A,B, and C) are distinguished based on textural and chemical properties (Table 10).

Table 10. Characteristics of colluvial genetic material units.

Genetic Material Unit	Dominant Source	Usual Textural Properties		Usual Chemical Properties	
		Fine Earth	Coarse Fragments	Calcareousness	pH
Colluvium A	Noncalcareous, medium to coarse grained, clastic bedrock (e.g. Gog Group quartzites)	60-85% sand and 0-10% clay	50-90%	Noncalc.	4.3-6.0
Colluvium B	Noncalcareous, medium to fine grained, clastic bedrock (e.g. Miette and Fernie Groups)	20-60% sand and 5-20% clay	35-90%	Noncalc.	4.3-6.0
Colluvium C	Medium to fine grained, carbonate and calcareous clastic bedrock	20-60% sand and 0-25% clay	35-90%	30-95% $CaCO_3$ equivalent	7.0-7.8

Colluvium A is normally coarse textured and noncalcareous (acidic). It is most extensive in the Main Ranges. Colluvium B is normally medium textured and noncalcareous (acidic). Colluvium C is usually medium textured and calcareous, hence neutral to mildly alkaline in reaction.

Low lime colluvial materials are differentiated into Colluvium A and B versus C based on pH of the sola developed on them. Colluvium A and B produce sola with pH $\leq$5.5 at a depth of 25 cm below the top of the B horizon. Colluvium C produces sola with pH >5.5. Colluvium that is texturally transitional between Colluvium A and B is distinguished by coarse fragments and soil development. Colluvium A generally has more coarse fragments, than B or C. Colluvium B is characterized by coarse fragments which are dominantly shales and slates. Soils developed on Colluvium A generally have deeply developed sola and thick, well developed eluvial (Ae) horizons. Colluvium B soils have thin sola and thin to absent Ae horizons. Further, the lithology of source bedrock aids in differentiating the colluvial material units.

Surface form is usually linear and expressed as blankets, veneers, and aprons. It is controlled by the amount of deposition and by the underlying bedrock. Slopes commonly range from 45 to 100%; their continuity may be broken by one or more bedrock outcrops. Soil creep and snow avalanching are the most common modifying processes. Slope failure, sheet erosion, solifluction, and cryoturbation occur locally.

MORAINAL GENETIC MATERIAL

Morainal material (till) is unsorted and unstratified drift deposited by and underneath a glacier without subsequent reworking by glacial meltwater. Morainal deposits occur extensively and are designated by the landform symbol $_M$. Morainal topography frequently dominates valley walls, valley floor benchlands, cirque basins, cols, and shoulders. Till is occasionally intimately associated with ice contact stratified genetic material along valley floors. Both are collectively considered glacial deposits. Three morainal genetic material units (Tills A,B, and C) are differentiated by textural and chemical properties (Table 11).

Table 11. Characteristics of morainal genetic material units.

Genetic Material Unit	Dominant Source	Usual Textural Properties		Usual Chemical Properties	
		Fine Earth	Coarse Fragments	Calcareousness	pH
Till A	Noncalcareous, medium to coarse grained, clastic bedrock (e.g. Gog Group quartzites)	60-85% sand and 0-10% clay	35-70%	Noncalc.	4.3-6.0
Till B	Noncalcareous, medium to fine grained, clastic bedrock (e.g. Miette and Fernie Groups)	30-60% sand and 5-25% clay	20-50%	Noncalc.	4.3-6.0
Till C	Medium to fine grained, carbonate and calcareous clastic bedrock	20-60% sand and 5-27% clay	20-50%	15-85% $CaCO_3$ equivalent	7.0-7.8

Till A is normally coarse textured and noncalcareous (acidic). It is most extensive in the Main Ranges. Till B is normally medium textured and noncalcareous (acidic). Till C is usually medium textured and calcareous (neutral to mildly alkaline).

Low lime Tills A and B are differentiated from Till C by having soils with pH $\leq$ 5.5 at a depth of 25 cm below the top of the B horizon. Till C is characterized by sola with pH >5.5. Till that is near the medium-coarse textural class boundary is recognized as Till A when it is dominated by a high coarse fragment content (most of which are subrounded quartzites). Soils developed on Till A generally have deeply developed sola and thick, well developed eluvial (Ae) horizons. Till B has coarse fragments which are dominantly shales and slates. The lithology of source bedrock further aids in distinguishing the three tills.

Surface form is usually linear on valley walls and forms blankets overlying inclined bedrock. Ridged and hummocky surfaces characterize benchlands, cirques, cols, and shoulders. These most often reflect underlying bedrock but in some areas reflect deposition or postglacial slope failure. Linear slopes reflecting stream erosion are common along some valley floors. Slopes commonly range from 5 to 70%. Slope failure, gullying, and snow avalanching are common surface modification processes that affect morainal landforms. Sheet erosion, soil creep, solifluction, and cryoturbation occur locally, the latter two at high elevations on the medium textured tills.

ICE CONTACT STRATIFIED GENETIC MATERIAL

Ice contact stratified drift is partially sorted material deposited by glacial ice but with concomitant and subsequent reworking, locally, by flowing and ponded glacial meltwater. The result is extreme vertical and lateral textural variability over short distances, except where coarse to medium grained source strata preclude the incorporation of abundant clay and silt sized particles. In essence, ice contact stratified drift, designated by the landform symbol M^{fg}, encompasses an intimate, random mixture of morainal, glaciofluvial, and, occasionally, glaciolacustrine sediments individually inseparable at a scale of 1:50,000. Ice contact stratified drift and

morainal material (till) are collectively considered glacial deposits. Two ice contact stratified genetic material units (Ice Contact Stratified Drift A and Ice Contact Stratified Drift B) are differentiated primarily on chemical properties and secondarily on textural properties (Table 12).

Table 12. Characteristics of ice contact stratified drift genetic material units.

Genetic Material Unit	Dominant Source	Usual Textural Properties		Usual Chemical Properties	
		Fine Earth	Coarse Fragments	Calcareousness	pH
Ice contact stratified Drift A	Noncalcareous, medium to coarse grained, clastic bedrock (e.g. Cog Group quartzites)	60-100% sand and 0-10% clay	5-70%	Noncalc.	4.3-6.0
Ice contact stratified Drift B	Medium to fine grained, carbonate and calcareous clastic bedrock	0-100% sand and 0-60% clay	5-70%	15-85% $CaCO_3$ equivalent	7.0-7.8

Ice Contact Stratified Drift A is normally noncalcareous (acidic) and coarse textured. It occurs primarily in the Main Ranges. A noncalcareous textured variant, derived primarily from Miette Group slates and shales, occurs in a few areas of the Main Ranges. Ice Contact Stratified Drift B is normally variably textured and calcareous (neutral to mildly alkaline).

Low lime, ice contact stratified materials are differentiated into Ice Contact Stratified Drift A or B based on pH of the sola developed on them. Ice Contact Stratified Drift A produces sola with pH $\leq$5.5 to a depth of 25 cm below the top of the B horizon. Soils associated with this genetic material unit tend to be deeply developed and have thick, well developed eluvial (Ae) horizons. Ice Contact Stratified Drift B produces soils with thin sola that have pH >5.5 to a depth of 25 cm below the top of the B horizon.

Ice contact stratified drift forms moraine-like landforms near valley floors, on valley floor benchlands, and, occasionally, on lower valley wall slopes. Hummocky, ridged, and inclined surface expressions are typical. These may be of strictly depositional origin, reflect the underlying bedrock, or be the result of stream erosion. Channelling (Eroded modifier, C.S.S.C. 1978b) and gullying are the most important modifying processes, the former often influencing landform surface expression. Other modifying processes of a more local distribution include slope failure, snow avalanching, sheet erosion and soil creep.

GLACIOFLUVIAL GENETIC MATERIAL

Glaciofluvial genetic material is deposited by bodies of flowing water in which the flow volume and sediment load are principaliy controlled by melting glacial ice. It is designated by the landform symbol F^G and is regarded as a proglacial deposit. Two glaciofluvial genetic material units (Glaciofluvial material A and B) are differentiated by chemical properties (Table 13).

Glaciofluvial material A is normally coarse textured and noncalcareous (acidic). Glaciofluvial material B is normally coarse textured and calcareous (neutral to moderately alkaline).

Table 13. Characteristics of glaciofluvial genetic material units.

Genetic Material Unit	Dominant Source	Usual Textural Properties		Usual Chemical Properties	
		Fine Earth	Coarse Fragments	Calcareousness	pH
Glaciofluvial material A	Noncalcareous glacial deposits	60-100% sand and 0-5% clay	35-70%	Noncalc.	4.3-6.0
Glaciofluvial material B	Calcareous glacial deposits	60-100% sand and 0-5% clay	35-70%	>10% $CaCO_3$ equivalent	7.0-8.0

Low lime glaciofluvial materials are differentiated into Glaciofluvial material A or B based on pH of the sola developed on them. Glaciofluvial material A produces sola with pH $\leq$5.5 to a depth of 25 cm below the top of the B horizon. Soils associated with this genetic material unit tend to be deeply developed and have thick, well developed eluvial (Ae) horizons. Glaciofluvial material B produces sola with pH >5.5 to a depth of 25 cm below the top of the B horizon.

Glaciofluvial deposits are distributed on valley floors and lower benchlands primarily in broad valleys at low elevations. Terrace is the most common surface form of stable landforms. Slopes are often complex with the majority of any surface made up of linear terrace treads with <5% slope. Short risers between terrace levels usually have slopes ranging from 30 to 70%. Actively aggrading glaciofluvial deposits have level and fan surface expressions with slopes <5%. Abandoned channels (Eroded modifier, C.S.S.C. 1978b) are often present.

FLUVIAL GENETIC MATERIAL

Fluvial (alluvial) material encompasses sediment deposited by stream channel sedimentation and mudflow processes (Thornbury 1954, Winder 1965, Russell 1972) and is designated by the landform symbol F. Two fluvial genetic material units (Fluvial material A and B) are differentiated based on chemical properties (Table 14).

Fluvial material A normally displays stratified coarse textures and is noncalcareous (acidic). Fluvial material B normally displays stratified coarse textures and is calcareous (neutral to moderately alkaline).

Low lime fluvial materials are differentiated into Fluvial material A or B based on pH of the sola developed on them. Fluvial material A produces sola with pH $\leq$5.5 to a depth of 25 cm below the top of the B horizon. Fluvial material B produces sola with pH >5.5.

Fluvial landscapes are most abundant along valley floors including benchlands. Two surface form groups, both with linear slopes, are characteristic. Level plains (floodplains), with slopes ranging from 0 to 2%, contain the major streams that formed them. Fans and aprons, with slopes ranging from 2 to 45%, occur along the toes of steeper slopes from which their sediments originated. Fluvial veneers and blankets occur in some cirque basin, col, shoulder, and valley floor localities. Active and abandoned channels (Eroded modifier, C.S.S.C. 1978b) are common on fluvial landform surfaces. Snow avalanching and solifluction are other modifying processes, but these occur locally, particularly at high elevations.

Table 14. Characteristics of fluvial genetic material units.

Genetic Material Unit	Dominant Source	Usual Textural Properties		Usual Chemical Properties	
		Fine Earth	Coarse Fragments	Calcareousness	pH
Fluvial material A	Noncalcareous bedrock, residual, landslide, colluvial, and glacial materials	15-90% sand and 0-25% clay, often stratified	0-70%, often stratified	Noncalc.	4.3-6.0
Fluvial material B	Calcareous bedrock, residual, landslide, colluvial, and glacial materials	15-90% sand and 0-25% clay, often stratified	0-70%, often stratified	5-85% $CaCO_3$ equivalent	7.0-8.0

FLUVIOLACUSTRINE GENETIC MATERIAL

Fluviolacustrine material encompasses relatively fine grained sediments deposited by slowly moving water, both glacial and nonglacial. The depositional environment is considered to be low energy fluvial but, by its textural characteristics, fluviolacustrine material does not fit the fluvial definition of C.S.S.C. (1978b). It is designated by the landform symbol [illegible]. Two fluviolacustrine genetic material units (Fluviolacustrine material A and B) are differentiated by chemical properties and geomorphic environments (Table 15).

Table 15. Characteristics of fluviolacustrine genetic material units.

Genetic Material Unit	Derivation	Usual Textural Properties		Usual Chemical Properties	
		Fine Earth	Coarse Fragments	Calcareousness	pH
Fluviolacustrine material A	Sheet erosion on other genetic materials, local deposition on other surfaces.	0-20% sand and 15-50% clay, often stratified	0-5%	pedogenic alteration	pedogenic alteration
Fluviolacustrine material B	Fluvial erosion of various deposits, low energy deposition on backwater portions of floodplains	0-20% sand and 10-40% clay, often stratified	0-5%	5-70% $CaCO_3$ equivalent	6.8-7.8

Fluviolacustrine material A encompasses fine textured and stratified, chemically altered, slope wash sediment deposited by nonglacial, unconfined water flow. It usually occurs as thin (usually <30 cm), mineral surface veneers overlying morainal, glaciolacustrine, and fluvial landforms with slopes of 0 to 30%. This material usually comprises the upper sola of soils where pedogenic weathering is strongest, hence the altered chemical properties. Fluviolacustrine material A comprised dominantly of reworked, Eolian material B has inherited the latter's primary mineral constituents and therefore, weathering frequently releases high amounts of free iron and aluminum oxide in the upper 30 cm.

Fluviolacustrine material B encompasses calcareous, fine, stratified sediment deposited by ponding of mainly glacial waters on backwater portions of floodplains, similar to those described by Smith (1972), and on delta-like floodplains at the heads of lakes, like those described by Smith (1975). It is the thickest and most stratified of the two fluviolacustrine material units and is confined to broad, valley floor floodplains where it overlies, interbeds with, and locally supplants fluvial and glaciofluvial sedements. Surface expression is level with slopes ranging from 0 to 1%. Slope continuity is frequently broken by numerous, shallow, abandoned and active stream channels meandering across the landscape (Eroded modifier, C.S.S.C. 1978b).

Fluviolacustrine genetic material is texturally similar to glaciolacustrine genetic material but exhibits greater textural variablility, a wider range of bulk density, and incorporation of thin, fibrous organic layers and pockets compared to the latter. Further, fluviolacustrine material is massive whereas glaciolacustrine material often exhibits varving and nonpedogenic subangular blocky structure. Glaciolacustrine material occurs in former lake basins and mantles, as blankets and veneers, gently sloping glacial landforms on benchlands. Fluviolacustrine sediments are associated with glacial, proglacial, and fluvial landforms as described above but these often do not occur in lake basins.

GLACIOLACUSTRINE GENETIC MATERIAL

Glaciolacustrine genetic material encompasses fine-grained sediment deposited in proglacial lake environments. It is designated by the landform symbol $^{L^G}$ and occurs primarily in the lower drainages of some tributary valleys of the Athabasca, North Saskatchewan and Bow River valleys. Glaciolacustrine material is texturally similar to fluviolacustrine genetic material but can be differentiated by stratification, bulk density, structural, and geomorphic environment parameters as outlined in the fluviolacustrine genetic material section.

Glaciolacustrine material is fine textured (0 - 10% sand and 30 - 50% clay) and calcareous (very strongly to extremely calcareous), hence neutral to mildly alkaline in reaction (pH 7.2 - 7.4). Noncalcareous glaciolacustrine material occurs rarely. Coarse fragments are usually absent but may range to 5% by volume.

Glaciolacustrine material commonly occurs as blankets and veneers overlying ridged, hummocky, and undulating glacial landforms of valley floor benchlands. Slopes commonly range from 0 to 10%.

EOLIAN GENETIC MATERIAL

Eolian sediment is deposited by wind. In Banff and Jasper, eolian deposits, also termed loess, are well sorted and dominated by silt (rarely <50%). Designated by the landform symbol ^{E}, Eolian Genetic Material is probably the most extensive unconsolidated mineral genetic material, but only in limited areas does it consistently exceed 30 cm in thickness. Two eolian genetic material units (Eolian material A and B) are differentiated based primarily on chemical properties (Table 16).

Eolian material A encompasses calcareous, medium textured sediment. Occurrences are restricted to valley floors, benchlands, and lower valley wall slopes in the Athabasca and Howse/North Saskatchewan River valleys at low elevations of the Montane Ecoregion. It exists

Table 16. Characteristics of eolian genetic material units.

Genetic Material Unit	Dominant Source	Usual Textural Properties		Usual Chemical Properties	
		Fine Earth	Coarse Fragments	Calcareousness	pH
Eolian material A	Braided river channels with extensive bare mineral soil	0-40% sand and 5-20% clay	0-5%	15-70% $CaCO_3$ equivalent	7.3-8.3
Eolian material B	Local unconsolidated and consolidated materials plus volcanic ash	10-50% sand and 0-25% clay	0-5%	pedogenic alteration	pedogenic alteration

as veneers and blankets overlying glacial deposits above the valley floor positions and as ridged landforms (dunes) on the Athabasca River valley floor. Slopes range from 5 to 70%. Processes modifying Eolian material A are primarily those which erode, mix, and rework surface layers. These include deflation, windthrow of trees, sheet erosion, stream channel overflow, and gullying. Eolian material A is presently aggrading with the rate of deposition decreasing upslope from the valley floors.

Eolian material B encompasses medium textured, chemically altered sediment. It occurs as thin (usually <30 cm), mineral surface veneers overlying a variety of landforms on all physiographic positions in all Ecoregions. It is most common on older, relatively stable surfaces such as morainal landscape. The deepest (15 to 30 cm) and most extensive deposits occur on stable surfaces in western Banff and southwestern Jasper. This material often comprises the upper sola of soils where pedogenic weathering is strongest, hence the altered chemical properties. Weathering of easily weatherable primary minerals is implicated in the characteristic strong pedogenic development in Eolian Material B. (Pettapiece and Pawluk 1972, Pawluk and Brewer 1975, King and Brewster 1976, and Smith 1979). Physical processes modifying Eolian material B are primarily those which erode, mix, and rework surface layers. These include sheet erosion, gully erosion, colluviation, avalanching, windthrow of trees, solifluction, and cryoturbation.

ORGANIC, CONSOLIDATED, AND ICE COMPONENTS

The organic component consists of peat deposits containing >30% organic matter by weight (>17% organic carbon) that may be as thin as 10 cm if they overlie bedrock but are otherwise >40 cm thick (C.S.S.C. 1978b). In Banff and Jasper the organic component is of limited areal extent and thinly mantles (rarely >1.2 m) glacial, proglacial, fluviolacustrine, and fluvial landforms in localities with ground water discharge and high water tables (very poor to poor drainage). It consists predominantly of moderately decomposed (mesic) fen peat designated by the landform symbol N, derived primarily from sedges and brown mosses. In several localities, the fen vegetation has been succeeded by open and closed forest. Fibric and humic layers and partially decomposed wood fragments may also occur in the section. The peat is medium acid to neutral (pH 5.5-7.5). Fen surface expression is horizontal or sloping and reflects the underlying mineral deposits. Slopes range from 0 to 10%.

The consolidated component (bedrock) consists of tightly packed lithified materials, excluding materials indurated by pedogenic processes, and is harder than 3 on Mohs' hardness scale. Bedrock underlies all other materials in the parks and outcrops in all areas, most often at high

elevations. Massive, resistant bedrock is more prominent in the landscape than recessive bedrock. It is the source of almost all unconsolidated mineral material in the parks.

The ice component encompasses ice and firn that forms by the compaction and recrystallization of snow. In Banff and Jasper, this includes glaciers, icefields, glacierettes, and firn. It occurs mainly in the Upper Subalpine and Alpine Ecoregions and is most extensive at higher elevations of the Main Ranges near the Continental Divide (Falconer et al. 1966). In some localities, ice is mantled by colluvial and landslide debris from adjacent steep slopes.

SOILS

FACTORS OF SOIL FORMATION

Five environmental factors are generally considered to affect soil formation. These are climate, living organisms, kind of parent material, relief, and time (or length of stability). The interaction of these soil-forming factors has resulted in many different kinds of soil throughout Banff and Jasper. The relative importance of each factor differs from place to place.

SOIL ORDERS IN BANFF AND JASPER

The soil taxonomy used in Banff and Jasper follows the Canadian System of Soil Classification (C.S.S.C. 1978b) Representatives of eight soil orders occur in the parks, including the Brunisolic, Luvisolic, Podzolic, Chernozemic, Cryosolic, Regosolic, Gleysolic, and Organic Orders.

BRUNISOLIC ORDER

The Brunisolic Order is broad in concept and, in Banff and Jasper, the most extensive relative to other orders, encompassing a wide range of characteristics. Four great groups occur in Banff and Jasper; their differentiation is based on solum reaction and A horizon characteristics.

Eutric and Melanic Brunisols have pH >5.5 at a depth of 25 cm below the top of the B horizon. These are associated with calcareous geomorphic materials. Dystric and Sombric Brunisols have pH $\leq$ 5.5 at a depth of 25 cm below the top of the B horizon. These are associated with non-calcareous geomorphic materials, including some with low lime content, and are less extensive than the Eutric and Melanic Brunisols.

Melanic and Sombric Brunisols are distinguished from Eutric and Dystric Brunisols by the presence of thick (10 cm or more) organo-mineral Ah horizons. Such horizons develop under non-forest vegetation where organic matter incorporation and humification are important processes.

B Horizon Characteristics of Brunisolic Soils

Brunisolic B horizons display a wide range of characteristics.

1. Brunisolic soils with weakly expressed and poorly differentiated B horizons are often associated with Regosolic soils on some geomorphically active terrain, such as steep colluvial landforms.
2. Eutric Brunisols occuring on warm, dry glacial and glaciolacustrine landforms, usually under lodgepole pine forests in the Montane and Lower Subalpine, frequently have B horizons with luvisol-like morphologies. Luvisolic soils are intimately associated. The Bm and Btj horizons of these Brunisolics display high clay contents compared to adjacent horizons, but structure and clay film development are weak and carbonate removal is incomplete.
3. Brunisolic soils with moderate or intermediate horizon development occur under intermediate mesoclimatic conditions or on stable genetic materials that do not

promote luvisolic or podzolic tendencies as a result of pedogenic weathering. Bm horizons of these Brunisolics are brownish colored and have low to moderate amounts of humus and free iron and aluminum oxides. Included are Eluviated Dystric Brunisols with duric tendencies (weak cementing) in lower B and BC horizons that are frequently developed on noncalcareous, coarse textured genetic material units, i.e. Till A, Ice Contact Stratified Drift A, and Glaciofluvial material A.

4. Brunisolic soils with strongly developed B horizons (podzolic tendencies) are associated with Podzolic soils under cool, moist Subalpine and Alpine conditions on stable landforms that include veneers of Eolian material B or Fluviolacustrine material A derived from Eolian material B (Table 8). The reddish, dark and strong brown Bm, Bfj, Bf or Bhf horizons of these Brunisolics are developed immediately above the parent material disconformity and have moderate to high, free iron and aluminum contents, weathered from the surface veneers. These B horizons also display increasing illuvial-humus content with elevation or with increasing wetness (imperfectly to poorly drained). This Brunisolic-Podzolic complex of soils is most extensive in western Banff and southwestern Jasper.

5. A variety of Brunisolic soils occurs under imperfectly to poorly drained conditions on sites affected by seepage. These are usually associated with Gleysolic and gleyed Podzolic soils. Gleyed Brunisols generally display weak mottling in a matrix background of moderate chroma within the upper 50 cm of mineral soil. A variety of climatic, geomorphic, and hydrologic factors contribute to the varying intensity of gleization across seepage affected landscape.

A Horizon Characteristics of Brunisolic Soils

The A horizons of Brunisolic soils exhibit a wide range of characteristics. They may be absent where current or recent disturbances have destroyed them or inhibited their development. On more stable slopes, eluvial (Ae) horizons are common under forest vegetation and, where >2 cm thick, are diagnostic for Eluviated subgroups within the Brunisolic Order. Organomineral Ah horizons associated with Brunisolic and other soils occur under tundra vegetation in the Alpine and Alpine-Upper Subalpine ecotone and under grassland and dry shrubland vegetation in the Subalpine. In both environments, the Ah horizon thickness is variable and largely controlled by the kind and degree of surface disturbance. The variable Ah horizon thickness results in the intimate association of Eutric with Melanic Brunisols and Dystric with Sombric Brunisols.

Upper sola of Brunisolics occurring under tundra vegetation tend to be acidic with low base saturation. Several Brunisolic subgroups are intimately associated, as are soils from the Podzolic, Regosolic, and Gleysolic Orders. Further, under heath tundra vegetation, graying A horizons with characteristics of Ah and Ae horizons (herein termed Ahe horizons) often replace or coexist with Ah horizons. Conversely, soils associated with Subalpine grasslands and dry shrublands are less variable than those under tundra vegetation. Upper sola of grassland and shrubland Brunisolics tend to have a neutral reaction with a high base saturation. Consequently, Ae and Ahe horizons giving Eluviated subgroups are absent and also, Dystric and Sombric Brunisols and Podzolics do not occur. Regosolic soils, however, are common associates. There is evidence that some of the soils occurring under grassland vegetation can also be classed as Dark Brown in the Chernozemic Order. Subalpine grasslands and dry shrublands are most common in, but not confined to, the Front Ranges and are usually associated with genetic material derived from Mesozoic strata.

LUVISOLIC ORDER

Gray Luvisols occur in association with Eutric Brunisols showing luvisolic tendencies in warm, dry, lower portions of the Lower Subalpine and throughout much of the Montane. They commonly occur on calcareous glacial and glaciolacustrine materials with rapidly to moderately well drained moisture regimes, most often under lodgepole pine forests. They are identified by eluvial Ae and illuvial Bt horizons. Structure and clay film development are more weakly expressed in Bt horizons of Banff and Jasper Luvisolics than in much of the forested areas in Alberta. Most of the Luvisolic soils have *bisequa* morphology and are classed as Brunisolic Gray Luvisols.

They have an Ae–Bm horizon sequence developed in very thin veneers of Eolian material B overlying a II Bt horizon. Orthic Gray Luvisols occur where the veneer is absent. Gleyed Brunisolic Gray Luvisols, characterized by weak mottling in middle to lower sola and C horizons, occur occasionally on seepage affected (imperfectly drained), low lime till.

PODZOLIC ORDER

Podzolic soils represent the most strongly developed soils in Banff and Jasper. They are associated with Eutric/Melanic or Dystric/Sombric Brunisols under cool, moist Subalpine and Alpine conditions on stable landforms (usually morainal) that include veneers of Eolian material B or Fluviolacustrine material A derived from Eolian material B.

The Brunisolic–Podzolic complex of soils is most common in western Banff and southwestern Jasper. Reddish to dark brown podzolic B horizons (C.S.S.C. 1978b) are diagnostic of Podzolic soils. These develop immediately above the parent material disconformity and contain high amounts (>0.6%) of free iron and aluminum weathered from the iron and aluminum containing minerals within the surfical veneers. Orthic Humo–Ferric Podzols, with podzolic Bf horizons, occur at moderate elevations under well to moderately well drained conditions with Engelmann spruce–subalpine fir and subalpine larch forests. However, illuvial humus content in the podzolic B horizons tends to increase with elevation. Consequently, Orthic Ferro–Humic Podzols, with podzolic Bhf horizons, are common under heath tundra vegetation in the Alpine and Alpine–Upper Subalpine ecotone. Podzolic soils with podzolic Bf, Bhf, or Bh horizons also occur under imperfectly to poorly drained conditions in the Subalpine and Alpine Ecoregions on landforms (usually morainal) that include the Fluviolacustrine material A veneers.

CHERNOZEMIC ORDER

Steeply sloping, southerly–facing Subalpine grasslands and dry shrublands are dominated by Regosolic and Brunisolic soils with organo–mineral Ah surface horizons. There is some new evidence, based on soil temperature data from our instrumented Mt. White grassland site in Banff, that some of the Humic Regosols and Melanic Brunisols (soils with $\geq$ 10 cm of Ah horizon), may, in fact, be classed as Chernozemic. Morphological and chemical data support classification in the Dark Brown Great Group of the Chernozemic Order. Chernozemic soils are not reflected in the Banff–Jasper Ecological Land Classification map legend because the temperature data are tentative and these soils are of limited areal extent.

CRYOSOLIC ORDER

Cryosolic soils represent the coldest soils found in Banff and Jasper. They have permafrost within 1 m and often within 50 cm of the ground surface. Cryosolic soils dominate many steep (30–70%), northerly–facing, forested (Engelmann spruce–subalpine fir) slopes in the Upper Subalpine in the Front Ranges subprovince north of Banff townsite. They are confined primarily to morainal landforms consisting of medium textured, variably calcareous till derived from Mesozoic strata.

Regosolic Static Cryosols are most abundant. Their genesis is commonly influenced by solifluction which disrupts horizon development and mixes geomorphic material in the thaw zone. Orthic Static Cryosols and, occasionally, Brunisolic Static Cryosols occur on sites where the solifluction process is inconsequential. Cryosolics often have thick (10–40 cm) organic layers (LFH horizons) mantling the mineral surface and are generally imperfectly drained except for a saturated zone at the frozen–unfrozen interface. Gleyed Eutric Brunisols and Gleyed Cumulic Regosols are frequently associated with Cryosolic soils. Achuff and Coen (1980) present data from a Brunisolic Static Cryosol site on Mt. White in Banff.

REGOSOLIC ORDER

Regosolic soils occur where active and recently active geomorphic processes of sufficient frequency and intensity inhibit pedogenic horizonation other than Ah horizon formation. They occur in all Ecoregions, on a variety of calcareous and noncalcareous geomorphic materials, on a

variety of slopes, and under several different kinds of vegetation. Processes that modify landform surfaces and contribute to Regosolic soil maintenance are avalanching, soil creep, fluvial erosion and deposition, eolian deflation and deposition, windthrow of trees, sheet erosion, gully erosion, solifluction, and cryoturbation. Landforms of recent age also have Regosolic soils. These include recent moraines, glaciofluvial floodplains, colluvial slopes, landslides, fluvial landforms, and eolian deposits.

Regosolic soils lack significant B horizons. The Regosol Great Group lacks surface Ah horizons or has Ah horizons <10 cm thick. Humic Regosols have Ah horizons ≥ 10 cm in thickness and are common on avalanched localities, grasslands, dry shrublands, and under tundra vegetation in the Alpine and Alpine–Upper Subalpine ecotone. Cumulic Subgroups of these Great Groups have buried organic and organomineral horizons and, occasionally, buried B horizons. Gleyed and Gleyed Cumulic Subgroups occur under imperfectly to poorly drained conditions and are often associated with Gleysolic and, less often, Organic soils. Under drier conditions, Regosolic soils are most often associated with Brunisolic soils.

GLEYSOLIC ORDER

Gleysolic soils occur under imperfectly to poorly drained conditions on glacial, glaciolacustrine, fluvial, and fluviolacustrine landforms throughout all Ecoregions in Banff and Jasper. They generally occupy depressional landscapes where seepage, surface water collection, and high water tables are important and occur under a variety of moist to wet (hygric to hydric) vegetation. They are most often associated with gleyed Brunisolic, gleyed Podzolic, gleyed Regosolic, and Organic soils.

Gleysolic soils are characterized by dull colors and/or strong mottling within 50 cm of the mineral surface, features indicative of intense reducing conditions. Rego Gleysols occur on sites where saturation is prolonged or geomorphic activity has inhibited pedogenic horizonation. Orthic Gleysols occur on stable sites where B horizons have developed. Thin organic layers of moderately decomposed fen peat commonly mantle Gleysolic soils, except where mineral material is actively aggrading. Some Gleysolic soils have thin Ah horizons but Humic Gleysols (Ah horizons ≥ 10 cm thick) are of minor importance.

ORGANIC ORDER

Organic soils occur most often in association with Gleysolic soils under poorly to very poorly drained conditions, primarily on glacial, fluvial, and fluviolacustrine landforms. They are characterized by accumulations of 40 cm or more of fen peat. Prolonged periods of ponding, without mineral material sedimentation, and fen vegetation promote the accumulation of peat. Organic soils also occur on slopes of up to 15% where seepage is an important factor throughout much of the year.

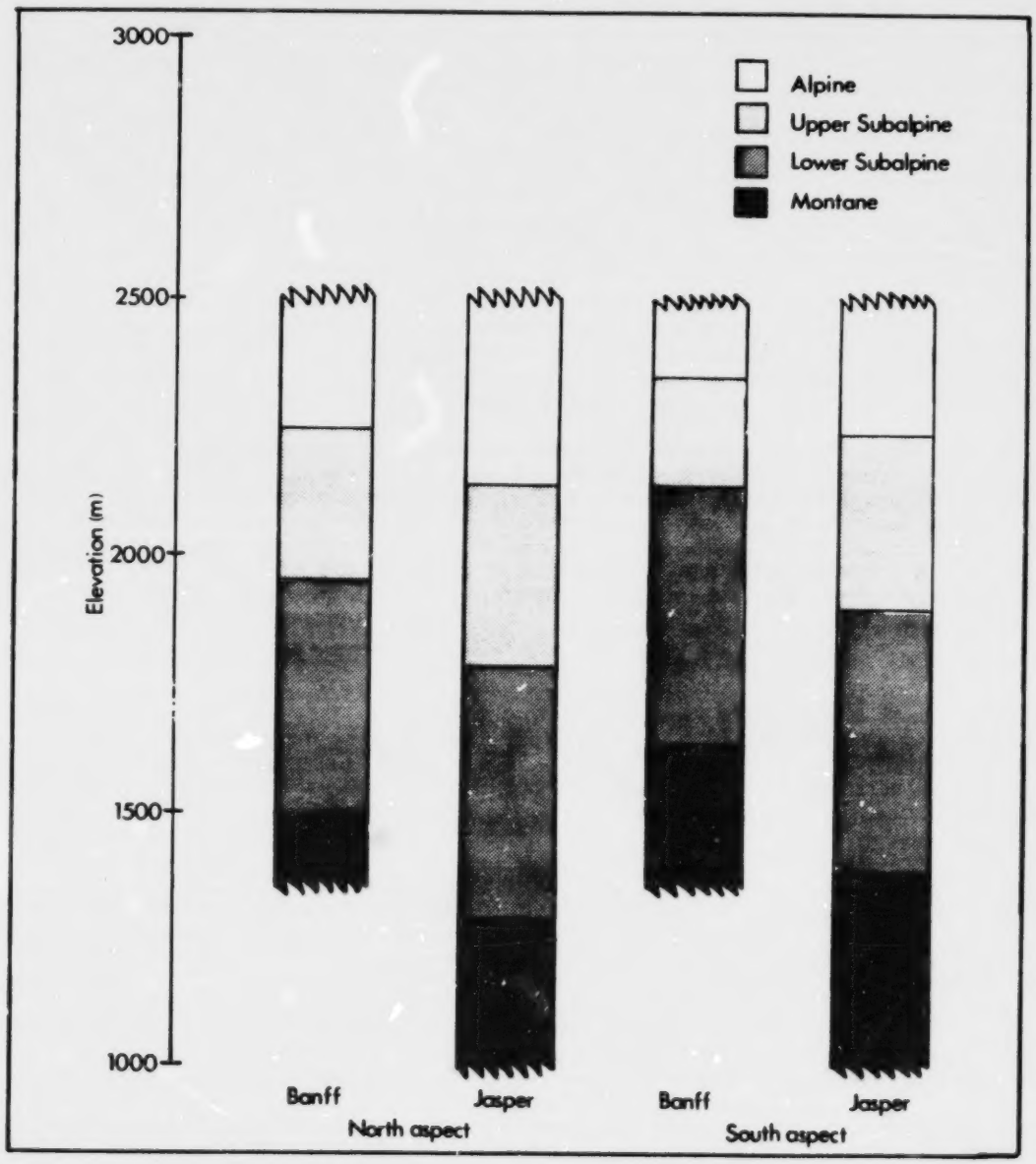
The peat is mainly moderately decomposed, hence the dominant Great Group is Mesisol. The peat accumulations rarely exceed 1.2 m in depth and the dominant Organic soils in Banff and Jasper are therefore Terric Mesisols.

VEGETATION

ECOREGIONS

Vegetation is used as the basis for definition of Ecoregions in the Ecological Land Classification. Ecoregional divisions reflect macroclimate and thus vegetational features (which primarily reflect climatic factors, rather than, for example, edaphic factors) are used to define the Ecoregions. From low to high elevation, three Ecoregions are recognized: Montane, Subalpine and Alpine (Fig. 6).

Fig. 6. Elevational ranges of Ecoregions and Ecoregion subunits in Banff and Jasper.



The Montane Ecoregion is characterized by v.t.s. dominated by Douglas fir (*Pseudotsuga menziesii*), white spruce (*Picea glauca*), and aspen poplar (*Populus tremuloides*), and by grasslands. Characteristic also is intermittent snow cover as a result of chinooks. The elevation of the Montane Ecoregion ranges from the lowest elevation in the parks (about 1350 m in Banff and 1000 m in Jasper) to about 1600 m in Banff and 1350 m in Jasper. This boundary is slightly lower on northerly aspects and slightly higher on southerly aspects.

The Subalpine Ecoregion occurs at altitudes above the Montane Ecoregion and below the unforested Alpine Ecoregion. The Subalpine Ecoregion is further divided into Lower Subalpine and Upper Subalpine portions. The predominant vegetation of the Lower Subalpine is closed coniferous forest. Mature forest is dominated by Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). Seral lodgepole pine (*Pinus contorta*) forests are common, especially at lower altitudes. The upper altitudinal boundary of the Lower Subalpine is generally about 2000 m in Banff and 1900 m in Jasper. The Upper Subalpine portion is broadly transitional between Lower Subalpine closed forest and treeless Alpine tundra. Compared to the Lower Subalpine, the Upper Subalpine is cooler and wetter, with greater snowfall, later snow melt, and a shorter growing season. Greater wind speed also appears to be a significant factor. Perhaps most characteristic are open forests and stunted tree growth forms (krummholz). Upper Subalpine closed forests typically contain some Alpine floristic elements. In southern Banff, forests containing subalpine larch (*Larix lyallii*) are characteristic of the Upper Subalpine. Lodgepole pine is generally absent and forests are usually dominated by Engelmann spruce and subalpine fir. The upper altitudinal boundary to the Alpine Ecoregion is about 2300 m in Banff and 2200 m in Jasper.

The treeless Alpine Ecoregion occurs at altitudes above the Upper Subalpine and reflects a cold, harsh climate. Alpine vegetation typically forms a complex, fine-scale mosaic in which microclimatic variations are reflected by marked changes in dominant species and v.t.s. Significant microclimatic factors include: aspect, wind exposure, time of snow melt, soil moisture, and snow depth. Dwarf shrub tundra dominated by yellow heather (*Phyllodoce glanduliflora*) and white mountain heather (*Cassiope mertensiana*) is characteristic of lower altitudes, while the highest altitude communities are usually dominated by lichens and occur on rocky shallow soil.

SUCCESSION AND CLIMAX

Succession deals with changes in vegetation through time. Primary succession occurs on sites without previous vegetation, such as newly deposited fluvial or morainal material, and may require more than a thousand years to reach a climax stage. Secondary succession occurs on sites which have been previously vegetated but have had the vegetation removed, as by fire. Secondary successions take less time than primary succession, with hundreds of years being typical.

Secondary succession following fire is the most common situation in Banff and Jasper and nearly all of the present forest has been subject to fire. For example, the Athabasca River Valley around Jasper townsite experienced major fires (>500 ha) in 24 of the years between 1665 and 1975, with most of the present forest originating after fires in 1889, 1847 and 1758 (Tande 1977). The potential complexity of successional relationships has been greatly simplified by a peak in fire frequency 100 to 120 years ago. This has resulted in the bulk of the lodgepole pine forests being in approximately the same successional stage. Earlier, preclimax stages are comparatively rare and areas of recent burn are limited, e.g. Survey Peak–Saskatchewan River Crossing and Flint's Park in Banff, lower Chaba River in Jasper.

A four stage successional sequence was used to classify v.t.s. in this report: early, intermediate, advanced and mature (climax). The early successional stage is usually heterogeneous and unstable in composition, often not referable to a v.t. and usually less than 50 years old since major disturbance or origin. The intermediate successional stage is moderately stable, more uniform in composition and dominated by species not climax for the site. Commonly, lodgepole pine dominates but Engelmann spruce and subalpine fir regeneration in the understory indicates an eventual dominance by these two species. Successionally intermediate communities are

generally 50 to 100 years old, although considerable variation occurs. Advanced successional communities are generally 80 to 200 years old and are dominated by a mixture of successional and climax species. In forested v.t.s., this is most typically a mixture of lodgepole pine (successional) and Engelmann spruce or subalpine fir (climax). The duration of this stage varies but 40 to 50 years is typical. The mature (climax) stage is stable, self-perpetuating and the end point of vegetation succession. In Banff and Jasper it generally takes 100 to 200 years to reach this stage in forest communities following initiation by fire.

In the Montane Ecoregion, mature forests are generally dominated by Douglas fir and white spruce which have often developed from lodgepole pine forests. However, on some dry sites, lodgepole pine forms climax forests. On the driest Montane sites, grasslands form the mature vegetation. Fire appears to be important in maintaining these grasslands and return to a climax condition following fire may take only ten years. Mature forests in the Subalpine Ecoregion are dominated by Engelmann spruce and subalpine fir which have often succeeded lodgepole pine forests. In the Upper Subalpine where lodgepole pine is less common, spruce and fir may be the initial tree colonizers after fire and a pine stage may be absent. Succession is slower in the Upper Subalpine, often requiring more than 250 years to reach a mature stage. Succession in the treeless Alpine Ecoregion is more difficult to document than in forests where tree ages provide easily obtained evidence of stand age. Fire is infrequent in the Alpine and water erosion and cryogenic processes are the main agents of disturbance which initiate secondary succession. Succession is very slow and recovery after trampling may take hundreds of years (Willard and Marr 1971).

Succession in wetlands differs from that on uplands. The rates appear to be slower although the usual herbaceous or shrubby vegetation makes stand history determination difficult. Since most wetland v.t.s. appear to be relatively stable over a 50 to 100 year period they have been designated successionally mature in this report. Landscape changes due to peat accumulation, stream aggradation and erosion, and cryoturbation are often coincident with vegetational succession on these sites, thus confounding successional history determination.

VEGETATION TYPE DESCRIPTIONS

This section contains abbreviated descriptions of 85 v.t.s., including both environmental characteristics and characteristic species with their typical cover values. The descriptions are arranged by physiognomic class: Closed Forest (C), Open Forest (O), Shrub (S), Low Shrub-Herb (L), and Herb-Dwarf Shrub (H), and numerically within each class (C1, C2, etc). More complete descriptions are in Volume II of this report.

CLOSED FOREST VEGETATION TYPES

C1: *Pseudotsuga menziesii/Elymus innovatus*
(Douglas fir/hairy wild rye)

Environment

Ecoregion: Montane
Moisture Regime: subxeric
Soils: Eutric Brunisols, Regosolics
Slope: moderate-steep
Aspect: southerly
Landform: colluvial, morainal

Characteristic Species (% cover)

Trees
Pseudotsuga menziesii 30-40

Shrubs

Juniperus communis	1–15	*Shepherdia canadensis*	1–5

Herbs–Dwarf Shrubs

Calamagrostis rubescens	10–35	*Fragaria virginiana*	<5
Elymus innovatus	5–20	*Achillea millefolium*	<5
Aster conspicuus	5–10	*Arctostaphylos uva-ursi*	<5

Bryoids

Hylocomium splendens	<1	*Peltigera aphthosa*	<1

Successional Status: mature
Related Vegetation Types: C5

C2: *Picea glauca/Thuidium abietinum*
(white spruce/fern moss)

Environment

Ecoregion: Montane
Moisture Regime: mesic
Soils: Cumulic Regosols, Eutric Brunisols
Slope: various
Aspect: northerly
Landform: eolian, fluvial

Characteristic Species (% cover)

Trees

Picea glauca	15–60

Shrubs

Rosa acicularis	<5	*Shepherdia canadensis*	<3

Herbs–Dwarf Shrubs

Elymus innovatus	1–10	*Pyrola secunda*	<3
Linnaea borealis	1–8		

Bryoids

Thuidium abietinum	20–95	*Hylocomium splendens*	<15

Successional Status: advanced–mature
Related Vegetation Types: C13, C26, C27, C37

C3: *Pinus contorta/Juniperus communis/Arctostaphylos uva-ursi*
(lodgepole pine/juniper/bearberry)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: subxeric–mesic
Soils: Eutric Brunisols, Regosolics
Slope: various
Aspect: southerly, westerly
Landform: morainal, colluvial, fluvial, glacio–fluvial

Characteristic Species (% cover)

Trees

Pinus contorta	15–40

Shrubs			
Juniperus communis	5-25	*Shepherdia canadensis*	5-15
Rosa acicularis	1-3		
Herbs-Dwarf Shrubs			
Arctostaphylos uva-ursi	10-25	*Linnaea borealis*	3-8
Elymus innovatus	5-15	*Fragaria virginiana*	<1
Solidago decumbens	<1	*Hedysarum sulphurescens*	<1
Bryoids			
Pleurozium schreberi	<1	*Drepanocladus uncinatus*	<1
Hylocomium splendens	<1	*Dicranum* spp.	<1
Epiphytes			
Letharia vulpina			

Successional Status: advanced-mature
Related Vegetation Types: C6, C9, C19

C4: *Picea glauca/Rosa acicularis/Equisetum arvense*
(white spruce/prickly rose/horsetail)

Environment

Ecoregion: Montane
Moisture Regime: subhygric-hygric
Soils: Gleysolics, Regosolics, Organics
Slope: gentle
Aspect: various
Landform: fluvial

Characteristic Species (% cover)

Trees			
Picea glauca	20-55		
Shrubs			
Rosa acicularis	5-15	*Cornus stolonifera*	3
Alnus tenuifolia	5	*Ribes lacustre*	1
Herbs-Dwarf Shrubs			
Equisetum arvense	30-50	*Equisetum pratense*	5-15
Linnaea borealis	5	*Mitella nuda*	1
Equisetum scirpoides	5	*Pyrola asarifolia*	<1
Bryoids			
Hylocomium splendens	15-50		

Successional Status: mature
Related Vegetation Types: C32

C5: *Picea glauca-Pseudotsuga menziesii/Hylocomium splendens*
(white spruce-Douglas fir/feathermoss)

Environment

Ecoregion: Montane-Lower Subalpine
Moisture Regime: mesic
Slope: various
Aspect: northerly

Soils: Eutric Brunisols, Regosolics, Gray Luvisols

Landform: fluvial, morainal

Characteristic Species (% cover)

Trees			
Picea glauca	20–40	*Pseudotsuga menziesii*	20–40
Shrubs			
Rosa acicularis	<1	*Shepherdia canadensis*	<1
Herbs–Dwarf Shrubs			
Pyrola secunda	<1	*Linnaea borealis*	<5
Aster conspicuus	<5	*Cornus canadensis*	<5
Elymus innovatus	<3		
Bryoids			
Hylocomium splendens	30–75	*Peltigera aphthosa*	3–5
Pleurozium schreberi	<1	*Ptilium crista-castrensis*	<1
Epiphytes			
Letharia vulpina		*Parmelia sulcata*	

Successional Status: mature
Related Vegetation Types: C1

C6: *Pinus contorta/Shepherdia canadensis/Aster conspicuus*
(lodgepole pine/buffaloberry/showy aster)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: mesic
Soils: Eutric Brunisols, Regosolics, Gray Luvisols

Slope: moderate
Aspect: southerly, westerly
Landform: morainal, fluvial, colluvial, glaciofluvial

Characteristic Species (% cover)

Trees			
Pinus contorta	25–45	*Picea* spp.	<10
Shrubs			
Shepherdia canadensis	15–30	*Juniperus communis*	1–5
Rosa acicularis	10–20	*Spiraea lucida*	1
Herbs–Dwarf Shrubs			
Aster conspicuus	10–20	*Elymus innovatus*	10–15
Linnaea borealis	3–5	*Arctostaphylos uva-ursi*	1–3
Arnica cordifolia	1–5	*Calamagrostis rubescens*	10–20
Bryoids			
Hylocomium splendens	10–30	*Pleurozium schreberi*	10–25
Peltigera aphthosa	1–3		
Epiphytes			
Letharia vulpina		*Alectoria* spp.	
Usnea spp.			

Successional Status: intermediate–advanced
Related Vegetation Types: C3, C9, C18, C19

C8: *Picea mariana–Pinus contorta/Salix myrtillifolia/Carex vaginata*
(black spruce–lodgepole pine/willow/sedge)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: hygric
Soils: Gleysolics, Organics

Slope: level–gentle
Aspect: northerly
Landform: morainal

Characteristic Species (% cover)

Trees			
Picea mariana	10–40	*Pinus contorta*	5–10
Shrubs			
Salix myrtillifolia	5–10	*Ledum groenlandicum*	5–20
Herbs–Dwarf Shrubs			
Carex vaginata	2–5	*Carex capillaris*	1
Arctostaphylos rubra	3	*Petasites palmatus*	<1
Equisetum arvense	<1	*Equisetum scirpoides*	<1
Bryoids			
Aulacomnium palustre	5–30	*Tomenthypnum nitens*	5
Hylocomium splendens	10–50	*Pleurozium schreberi*	5–20
Peltigera aphthosa	<1		

Successional Status: advanced–mature
Related Vegetation Types: O11

C9: *Pinus contorta/Vaccinium caespitosum*
(lodgepole pine/dwarf bilberry)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: mesic–subxeric
Soils: Eutric and Dystric Brunisols, Gray Luvisols

Slope: level
Aspect: southerly
Landform: fluvial, glaciofluvial, glaciolacustrine

Characteristic Species (% cover)

Trees			
Pinus contorta	25–40		
Shrubs			
Shepherdia canadensis	6	*Rosa acicularis*	1
Juniperus communis	1		
Herbs–Dwarf Shrubs			
Vaccinium caespitosum	10–25	*Calamagrostis rubescens*	2–10
Linnaea borealis	5–10	*Arctostaphylos uva-ursi*	6
Elymus innovatus	5–10		

Bryoids			
Pleurozium schreberi	10–25	*Peltigera aphthosa*	3–5
Epiphytes			
Alectoria spp.		*Letharia vulpina*	

Successional Status: intermediate–advanced
Related Vegetation Types: C3, C6, C18, C19, C35

C10: *Pinus contorta/Alnus crispa/Hylocomium splendens*
(lodgepole pine/green alder/feathermoss)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: mesic
Soils: Eutric and Dystric Brunisols
Slope: various
Aspect: northerly
Landform: morainal

Characteristic Species (% cover)

Trees			
Pinus contorta	10–55	*Picea glauca*	<20
Shrubs			
Alnus crispa	10–50	*Shepherdia canadensis*	<10
Rosa acicularis	<5	*Viburnum edule*	<5
Menziesia glabella	<3		
Herbs–Dwarf Shrubs			
Linnaea borealis	<10	*Cornus canadensis*	<10
Elymus innovatus	3–15	*Pyrola secunda*	<3
Pyrola asarifolia	<3	*Arnica cordifolia*	<5
Aster conspicuus	<10		
Bryoids			
Hylocomium splendens	15–75	*Pleurozium schreberi*	5–45
Peltigera aphthosa	<5	*Ptilium crista-castrensis*	<10

Successional Status: intermediate
Related Vegetation Types: C6, C11, C14, C19

C11: *Pinus contorta–Picea* spp./*Hylocomium splendens*
(lodgepole pine/feathermoss)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: mesic
Soils: Eutric Brunisols
Slope: gentle
Aspect: northerly
Landform: glacial

Characteristic Species (% cover)

Trees			
Pinus contorta	5–65	*Picea* spp.	<30

Shrubs			
Ledum groenlandicum	<10	*Shepherdia canadensis*	<5
Rosa acicularis	<2		
Herbs-Dwarf Shrubs			
Linnaea borealis	<25	*Cornus canadensis*	<5
Pyrola secunda	<3	*Elymus innovatus*	<5
Arnica cordifolia	<10		
Bryoids			
Hylocomium splendens	30-60	*Ptilium crista-castrensis*	5-10
Pleurozium schreberi	10-50	*Peltigera aphthosa*	5-15
Epiphytes			
Cetraria pinastri		*Letharia vulpina*	
Hypogymnia physodes			

Successional Status: intermediate-advanced
Related Vegetation Types: C13, C19, C20, C29

C12: *Picea engelmannii-Pinus albicaulis/Menziesia glabella*
(Engelmann spruce-whitebark pine/false azalea)

Environment

Ecoregion: Lower Subalpine
Moisture Regime: mesic
Soils: Eutric and Dystric Brunisols
Slope: steep
Aspect: various
Landform: morainal, colluvial

Characteristic Species (% cover)

Trees			
Picea engelmannii	10-20	*Pinus albicaulis*	10-25
Abies lasiocarpa	5-20		
Shrubs			
Menziesia glabella	20-75	*Ledum groenlandicum*	5-10
Abies lasiocarpa	3-15		
Herbs-Dwarf Shrubs			
Vaccinium scoparium	5-60	*Vaccinium membranaceum*	1-5
Empetrum nigrum	5-10	*Vaccinium vitis-idaea*	<1
Bryoids			
Pleurozium schreberi	20-35	*Dicranum scoparium*	5-10
Peltigera aphthosa	1-2	*Cladonia* spp.	1-5
Epiphytes			
Letharia vulpina		*Parmeliopsis ambigua*	
Parmeliopsis hyperopta			

Successional Status: mature
Related Vegetation Types: C14

C13: *Picea engelmannii-Abies lasiocarpa/Hylocomium splendens*
(Engelmann spruce-subalpine fir/feathermoss)

Environment

Ecoregion: Lower Subalpine
Moisture Regime: mesic–subhygric
Soils: Eutric and Dystric Brunisols, Regosolics
Slope: various
Aspect: various
Landform: glacial, colluvial, glaciofluvial, fluvial

Characteristic Species (% cover)

Trees			
Picea engelmannii	20–55	*Abies lasiocarpa*	<15
Shrubs			
Abies lasiocarpa	5–15	*Picea engelmannii*	<10
Herbs–Dwarf Shrubs			
Pyrola secunda	<3	*Arnica cordifolia*	<5
Equisetum scirpoides	<5	*Linnaea borealis*	<10
Bryoids			
Hylocomium splendens	30–75	*Pleurozium schreberi*	10–60
Ptilium crista-castrensis	<15	*Barbilophozia lycopodioides*	<5
Peltigera aphthosa	<10	*Cladonia ecmocyna*	<1
Epiphytes			
Letharia vulpina		*Parmeliopsis ambigua*	

Successional Status: mature
Related Vegetation Types: C5, C11, C14, C15, C24, C30, C31

C14: *Picea engelmannii–Abies lasiocarpa/Menziesia glabella/Vaccinium scoparium*
(Engelmann spruce–subalpine fir/false azalea)

Environment

Ecoregion: Lower Subalpine
Moisture Regime: mesic–subhygric
Soils: Eutric and Dystric Brunisols, Humo–Ferric Podzols
Slope: various
Aspect: northerly
Landform: glacial, colluvial

Characteristic Species (% cover)

Trees			
Picea engelmannii	15–75	*Abies lasiocarpa*	5–15
Shrubs			
Menziesia glabella	20–70	*Ledum groenlandicum*	<10
Herbs–Dwarf Shrubs			
Vaccinium scoparium	5–40	*Vaccinium membranaceum*	5–15
Vaccinium myrtillus	5–25	*Arnica cordifolia*	<10
Linnaea borealis	3–15	*Cornus canadensis*	<5
Lycopodium annotinum	<5		
Bryoids			
Pleurozium schreberi	25–60	*Hylocomium splendens*	25–60

Ptilium crista-castrensis	5-15	*Barbilophozia lycopodioides*	5-20
Peltigera aphthosa	<10		

Successional Status: mature
Related Vegetation Types: C13, C20, C21

C15: *Picea engelmannii-Abies lasiocarpa/Vaccinium scoparium*
(Engelmann spruce-subalpine fir/grouseberry)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: mesic
Soils: Eutric and Dystric Brunisols, Humo-Ferric Podzols
Slope: various
Aspect: southerly
Landform: morainal

Characteristic Species (% cover)

Trees			
Picea engelmannii	10-40	*Abies lasiocarpa*	<25
Shrubs			
Abies lasiocarpa	5-30	*Picea engelmannii*	<5
Herbs-Dwarf Shrubs			
Vaccinium scoparium	15-60	*Arnica cordifolia*	<10
Epilobium angustifolium	<5	*Pedicularis bracteosa*	<10
Erigeron peregrinus	<5		
Bryoids			
Pleurozium schreberi	10-30	*Dicranum scoparium*	5-25
Barbilophozia hatcheri	5-20	*Barbilophozia lycopodioides*	5-20
Peltigera aphthosa	<10		
Epiphytes			
Letharia vulpina		*Alectoria* spp.	

Successional Status: mature
Related Vegetation Types: C14, C21, C23, C34, O10

C16: *Populus tremuloides/Elymus innovatus-Lathyrus ochroleucus*
(aspen/hairy wild rye-peavine)

Environment

Ecoregion: Montane-Lower Subalpine
Moisture Regime: mesic
Soils: Eutric Brunisols, Regosolics, Gray Luvisols
Slope: gentle
Aspect: southerly
Landform: fluvial, morainal

Characteristic Species (% cover)

Trees	
Populus tremuloides	20-60

Shrubs			
Rosa acicularis	5–10	*Shepherdia canadensis*	5–15
Juniperus communis	<1		
Herbs–Dwarf Shrubs			
Elymus innovatus	15–40	*Calamagrostis rubescens*	15–40
Lathyrus ochroleucus	1–3	*Aster conspicuus*	<1
Fragaria virginiana	1–5	*Galium boreale*	<1
Vicia americana	<1	*Achillea millefolium*	<1

Successional Status: intermediate–mature
Related Vegetation Types: C22

C17: *Populus balsamifera/Shepherdia canadensis*
(balsam poplar/buffaloberry)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: mesic
Soils: Regosolics
Slope: gentle
Aspect: various
Landform: fluvial

Characteristic Species (% cover)

Trees			
Populus balsamifera	15–50	*Picea glauca*	<10
Shrubs			
Shepherdia canadensis	10–70	*Populus balsamifera*	<10
Rosa acicularis	<5	*Cornus stolonifera*	<10
Herbs–Dwarf Shrubs			
Elymus innovatus	10–30	*Fragaria virginiana*	<3
Linnaea borealis	<10	*Epilobium angustifolium*	<1
Aster ciliolatus	<5		

Successional Status: early–intermediate
Related Vegetation Types: C28

C18: *Pinus contorta/Shepherdia canadensis/Vaccinium scoparium*
(lodgepole pine/buffaloberry/grouseberry)

Environment

Ecoregion: Lower Subalpine
Moisture Regime: mesic
Soils: Eutric and Dystric Brunisols, Gray Luvisols
Slope: various
Aspect: various
Landform: glacial

Characteristic Species (% cover)

Trees			
Pinus contorta	25–50	*Picea* spp.	3–5
Shrubs			
Shepherdia canadensis	10–30	*Juniperus communis*	1–5

Herbs–Dwarf Shrubs			
Vaccinium scoparium	20–45	*Elymus innovatus*	5–25
Linnaea borealis	3–10	*Arnica cordifolia*	1–5
Cornus canadensis	1–3	*Arctostaphylos uva-ursi*	1–2
Bryoids			
Pleurozium schreberi	20–40	*Hylocomium splendens*	5–15
Dicranum spp.	1–3	*Peltigera aphthosa*	2–5
Epiphytes			
Letharia vulpina			

Successional Status: intermediate–advanced
Related Vegetation Types: C6, C9, C15, C19

C19: *Pinus contorta/Shepherdia canadensis/Linnaea borealis*
(lodgepole pine/buffaloberry/twinflower)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: mesic
Soils: Eutric and Dystric Brunisols, Gray Luvisols
Slope: various
Aspect: southerly, westerly
Landform: glacial

Characteristic Species (% cover)

Trees			
Pinus contorta	30–50	*Picea* spp.	1–10
Shrubs			
Shepherdia canadensis	10–30	*Juniperus communis*	1–3
Rosa acicularis	<1–2		
Herbs–Dwarf Shrubs			
Linnaea borealis	10–25	*Calamagrostis rubescens*	5–30
Elymus innovatus	3–15	*Arctostaphylos uva-ursi*	1–3
Arnica cordifolia	1–3		
Bryoids			
Hylocomium splendens	20–40	*Pleurozium schreberi*	20–35
Peltigera aphthosa	1–3		
Epiphytes			
Letharia vulpina		*Cetraria pinastri*	
Alectoria spp.			

Successional Status: intermediate–advanced
Related Vegetation Types: C3, C6, C9, C18

C20: *Pinus contorta/Menziesia glabella/Vaccinium scoparium*
(lodgepole pine/false azalea/grouseberry)

Environment

Ecoregion: Lower Subalpine
Moisture Regime: mesic
Soils: Eutric and Dystric Brunisols

Slope: various
Aspect: northerly, easterly
Landform: morainal, glaciofluvial

Characteristic Species (% cover)

Trees			
Pinus contorta	15–65	*Picea engelmannii*	<10
Abies lasiocarpa	<10		
Shrubs			
Menziesia glabella	10–70	*Shepherdia canadensis*	<10
Ledum groenlandicum	<10	*Rhododendron albiflorum*	<10
Herbs–Dwarf Shrubs			
Vaccinium scoparium	10–40	*Vaccinium membranaceum*	10–35
Linnaea borealis	<10	*Arnica cordifolia*	<15
Cornus canadensis	<5	*Elymus innovatus*	<5
Bryoids			
Pleurozium schreberi	25–70	*Ptilium crista-castrensis*	<10
Hylocomium splendens	10–40	*Peltigera aphthosa*	<5
Epiphytes			
Letharia vulpina			

Successional Status: intermediate
Related Vegetation Types: C14, C18

C21: *Picea engelmannii–Abies lasiocarpa/Vaccinium membranaceum/Barbilophozia lycopodioides*
(Engelmann spruce–subalpine fir/tall bilberry/liverwort)

Environment

Ecoregion: Lower–Upper Subalpine
Moisture Regime: mesic
Soils: Eutric and Dystric Brunisols, Humo-Ferric Podzols

Slope: various
Aspect: various
Landform: morainal, colluvial

Characteristic Species (% cover)

Trees			
Picea engelmannii	5–35	*Abies lasiocarpa*	<20
Shrubs			
Rhododendron albiflorum	10–60	*Abies lasiocarpa*	5–20
Herbs–Dwarf Shrubs			
Vaccinium membranaceum	5–35	*Phyllodoce empetriformis*	<10
Vaccinium scoparium	<15	*Empetrum nigrum*	<10
Arnica cordifolia	<5		
Bryoids			
Pleurozium schreberi	15–50	*Barbilophozia lycopodioides*	5–40
Dicranum scoparium	<15	*Peltigera aphthosa*	<5
Cladonia ecmocyna	<5		

Epiphytes
Letharia vulpina *Parmeliopsis ambigua*

Successional Status: mature
Related Vegetation Types: C14, C15, C24

C22: *Populus tremuloides/Elymus innovatus–Aster conspicuus*
(aspen/hairy wild rye–showy aster)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: mesic–subxeric
Soils: Regosolics, Eutric Brunisols
Slope: steep
Aspect: southerly
Landform: colluvial, fluvial, glacial

Characteristic Species (% cover)

Trees			
Populus tremuloides	20–40		
Shrubs			
Populus tremuloides	10–20	*Shepherdia canadensis*	1–2
Rosa acicularis	3–20		
Herbs–Dwarf Shrubs			
Elymus innovatus	20–50	*Arctostaphylos uva-ursi*	10–40
Aster conspicuus	5–10	*Fragaria virginiana*	<1
Achillea millefolium	<1	*Hedysarum sulphurescens*	<1
Bryoids			
Tortula ruralis	<1		

Successional Status: intermediate
Related Vegetation Types: C16

C23: *Larix lyallii–Abies lasiocarpa/Vaccinium scoparium–Antennaria lanata*
(subalpine larch–subalpine fir/grouseberry–everlasting)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: mesic
Soils: Eutric and Dystric Brunisols, Humo–Ferric Podzols
Slope: various
Aspect: various
Landform: colluvial, morainal

Characteristic Species (% cover)

Trees			
Larix lyallii	10–60	*Abies lasiocarpa*	<20
Shrubs			
Abies lasiocarpa	5–20	*Larix lyallii*	5–15

Herbs–Dwarf Shrubs

Vaccinium scoparium	5–40	*Phyllodoce glanduliflora*	<25
Antennaria lanata	<10	*Erigeron peregrinus*	<5
Valeriana sitchensis	<10	*Arnica latifolia*	5–20
Cassiope mertensiana	<20		

Bryoids

Barbilophozia spp.	5–30	*Polytrichum juniperinum*	<5

Epiphytes
Letharia vulpina

Successional Status: mature
Related Vegetation Types: C15, C21, O10

C24: *Picea engelmannii–Abies lasiocarpa/Salix vestita/Cassiope tetragona*
(Engelmann spruce–subalpine fir/rock willow/white mountain heather)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: mesic–subhygric
Soils: Static Cryosols, Eutric Brunisols
Slope: moderate–steep
Aspect: northerly
Landform: morainal, colluvial

Characteristic Species (% cover)

Trees

Picea engelmannii	10–30	*Abies lasiocarpa*	3–10

Shrubs

Salix vestita	5–30	*Abies lasiocarpa*	10–20
Picea engelmannii	1–5		

Herbs–Dwarf Shrubs

Cassiope tetragona	10–35	*Phyllodoce glanduliflora*	1–10
Equisetum scirpoides	2–15		

Bryoids

Hylocomium splendens	10–50	*Pleurozium schreberi*	5–30
Dicranum scoparium	5–10	*Drepanocladus uncinatus*	1–5
Barbilophozia lycopodioides	1–5	*Peltigera aphthosa*	1–5

Epiphytes
Letharia vulpina *Hypogymnia austerodes*

Successional Status: mature
Related Vegetation Types: C34, O12, O14

C26: *Picea glauca/Shepherdia canadensis/Thuidium abietinum*
(white spruce/buffaloberry/fern moss)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: mesic
Soils: Regosolics
Slope: various
Aspect: northerly
Landform: eolian, fluvial

Characteristic Species (% cover)

Trees			
Picea glauca	25–30		
Shrubs			
Shepherdia canadensis	10–30	*Rosa acicularis*	<5
Herbs–Dwarf Shrubs			
Elymus innovatus	5–20	*Arctostaphylos uva-ursi*	3–15
Linnaea borealis	5–20	*Carex concinna*	<3
Pyrola secunda	<3		
Bryoids			
Thuidium abietinum	50–70	*Peltigera aphthosa*	<1
Peltigera canina	<1		

Successional Status: mature
Related Vegetation Types: C2, C27, C37

C27: *Picea glauca/Rosa acicularis/Thuidium abietinum*
(white spruce/prickly rose/fern moss)

Environment

Ecoregion: Montane
Moisture Regime: mesic
Soils: Regosolics
Slope: level–moderate
Aspect: northerly
Landform: eolian, fluvial

Characteristic Species (% cover)

Trees			
Picea glauca	25–35		
Shrubs			
Rosa acicularis	10–20	*Shepherdia canadensis*	<5
Lonicera dioica	<5		
Herbs–Dwarf Shrubs			
Elymus innovatus	10–20	*Linnaea borealis*	2–12
Carex eburnea	5–10	*Geocaulon lividum*	<1
Zygadenus elegans	<1	*Smilacina stellata*	<1
Fragaria virginiana	<1		
Bryoids			
Thuidium abietinum	15–50		

Successional Status: mature
Related Vegetation Types: C2, C26, C37

C28: *Populus balsamifera/Equisetum pratense*
(balsam poplar/horsetail)

Environment

Ecoregion: Montane
Moisture Regime: hygric–subhygric
Soils: Regosolics
Slope: gentle
Aspect: various
Landform: fluvial

Characteristic Species (% cover)

Trees			
Populus balsamifera	35–55	*Picea glauca*	<10
Shrubs			
Rosa acicularis	2	*Viburnum edule*	<5
Herbs–Dwarf Shrubs			
Equisetum pratense	<60	*Equisetum arvense*	<20
Mertensia paniculata	<15	*Rubus pubescens*	<5
Petasites palmatus	<2	*Vicia americana*	1
Galium triflorum	<1		
Bryoids			
Bryum caespiticium	<1	*Brachythecium salebrosum*	<1

Successional Status: intermediate
Related Vegetation Types: C16, C17

C29: *Pinus contorta/Ledum groenlandicum* (lodgepole pine/Labrador tea)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: mesic
Soils: Eutric and Dystric Brunisols, Gray Luvisols
Slope: various
Aspect: northerly
Landform: morainal, fluvial, eolian

Characteristic Species (% cover)

Trees			
Pinus contorta	20–45	*Picea* spp.	>10
Shrubs			
Ledum groenlandicum	10–40	*Shepherdia canadensis*	1–5
Salix glauca	1–5	*Juniperus communis*	1–3
Herbs–Dwarf Shrubs			
Vaccinium scoparium	5–15	*Vaccinium vitis-idaea*	3–5
Linnaea borealis	3–5	*Elymus innovatus*	1–5
Arnica cordifolia	1–5	*Cornus canadensis*	1–5
Bryoids			
Pleurozium schreberi	35–45	*Ptilium crista-castrensis*	5–15
Hylocomium splendens	20–35	*Peltigera aphthosa*	1–3
Epiphytes			
Letharia vulpina			

Successional Status: intermediate–advanced
Related Vegetation Types: C30

C30: *Picea engelmannii–Abies lasiocarpa/Ledum groenlandicum/Empetrum nigrum*
(Engelmann spruce–subalpine fir/Labrador tea/crowberry)

Environment

Ecoregion: Lower Subalpine
Moisture Regime: mesic
Soils: Eutric and Dystric Brunisols

Slope: gentle–moderate
Aspect: northerly, easterly
Landform: eolian, morainal

Characteristic Species (% cover)

Trees			
Picea engelmannii	20–40	*Abies lasiocarpa*	5–10
Pinus contorta	<5		
Shrubs			
Ledum groenlandicum	10–30	*Abies lasiocarpa*	3–10
Picea engelmannii	3–5	*Salix glauca*	1–3
Herbs–Dwarf Shrubs			
Empetrum nigrum	8–20	*Vaccinium vitis-idaea*	3–5
Elymus innovatus	5	*Vaccinium scoparium*	5–10
Arnica cordifolia	1–3	*Cornus canadensis*	1–3
Bryoids			
Hylocomium splendens	30–50	*Ptilium crista-castrensis*	5–15
Pleurozium schreberi	15–35	*Peltigera aphthosa*	1–3
Epiphytes			
Letharia vulpina		*Cetraria pinastri*	

Successional Status: mature
Related Vegetation Types: C29

C31: *Picea engelmannii–Abies lasiocarpa/Elymus innovatus–Arnica cordifolia–Linnaea borealis/Hylocomium splendens*
(Engelmann spruce–subalpine fir/hairy wild rye–heartleaf arnica–twinflower/feathermoss)

Environment

Ecoregion: Lower Subalpine
Moisture Regime: mesic
Soils: Eutric Brunisols

Slope: moderate
Aspect: various
Landform: fluvial, glacial

Characteristic Species (% cover)

Trees			
Picea engelmannii	30–45	*Abies lasiocarpa*	1–5
Pinus contorta	<5		
Shrubs			
Juniperus communis	<5	*Shepherdia canadensis*	<5
Herbs–Dwarf Shrubs			
Elymus innovatus	5–10	*Arnica cordifolia*	5–10
Linnaea borealis	5–15	*Vaccinium scoparium*	5–15

Bryoids
Hylocomium splendens 20-50
Peltigera aphthosa <10
Pleurozium schreberi 20-30

Epiphytes
Usnea sorediifera
Bryoria glabra

Successional Status: mature
Related Vegetation Types: C13, C33

C32: *Picea engelmannii/Equisetum arvense/Hylocomium splendens*
(Engelmann spruce/horsetail/feathermoss)

Environment

Ecoregion: Lower Subalpine
Moisture Regime: mesic-subhygric
Soils: Regosolics, Gleysolics
Slope: gentle-moderate
Aspect: various
Landform: fluvial

Characteristic Species (% cover)

Trees
Picea engelmannii 20-40

Herbs-Dwarf Shrubs
Equisetum arvense 20-50
Elymus innovatus <5
Mertensia paniculata <1
Arnica cordifolia 3-5
Linnaea borealis 5
Mitella nuda <1

Bryoids
Hylocomium splendens 25-50
Ptilium crista-castrensis 5
Pleurozium schreberi 10
Peltigera aphthosa 3

Successional Status: mature
Related Vegetation Types: C4

C33: *Picea engelmannii/Elymus innovatus*
(Engelmann spruce/hairy wild rye)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: mesic-subxeric
Soils: Eutric Brunisols, Regosolics
Slope: various
Aspect: southerly
Landform: morainal, colluvial

Characteristic Species (% cover)

Trees
Picea engelmannii 15-50
Pinus contorta <10

Shrubs
Picea engelmannii 5-15
Juniperus communis <5
Shepherdia canadensis <5

Herbs-Dwarf Shrubs			
Elymus innovatus	5-40	*Arctostaphylos uva-ursi*	<10
Linnaea borealis	1-10	*Hedysarum sulphurescens*	<10
Arnica cordifolia	2-10	*Fragaria virginiana*	<5
Zygadenus elegans	<5		
Bryoids			
Hylocomium splendens	<15	*Pleurozium schreberi*	<10
Peltigera aphthosa	<10		
Epiphytes			
Letharia vulpina			

Successional Status: mature
Related Vegetation Types: C31

C34: *Picea engelmannii-Abies lasiocarpa/Phyllodoce glanduliflora/Hylocomium splendens*
(Engelmann spruce-subalpine fir/heather/feathermoss)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: mesic
Soils: Eutric and Dystric Brunisols, Humo-Ferric Podzols
Slope: moderate-steep
Aspect: northerly, easterly
Landform: morainal

Characteristic Species (% cover)

Trees			
Picea engelmannii	15-30	*Abies lasiocarpa*	5-25
Shrubs			
Abies lasiocarpa	10-50	*Picea engelmannii*	1-5
Herbs-Dwarf Shrubs			
Phyllodoce glanduliflora	10-25	*Vaccinium scoparium*	5-15
Cassiope mertensiana	5-10	*Cassiope tetragona*	3-5
Bryoids			
Pleurozium schreberi	15-45	*Hylocomium splendens*	10-40
Dicranum scoparium	5-20	*Drepanocladus uncinatus*	5-10
Barbilophozia lycopodioides	1-5	*Peltigera aphthosa*	1-5
Cladonia ecmocyna	1-3		
Epiphytes			
Letharia vulpina		*Parmeliopsis hyperopta*	
Parmeliopsis ambigua			

Successional Status: mature
Related Vegetation Types: C13, C15, C24, O10

C35: *Pinus contorta-(Picea engelmannii)/Empetrum nigrum /Cladonia mitis*
(lodgepole pine-(Engelmann spruce)/crowberry/lichen)

Environment

Ecoregion: Lower Subalpine
Moisture Regime: subxeric
Soils: Dystric Brunisols
Slope: level-moderate
Aspect: various
Landform: glaciofluvial, glacial

Characteristic Species (% cover)

Trees			
Pinus contorta	25-35	*Picea engelmannii*	5-8
Herbs-Dwarf Shrubs			
Empetrum nigrum	15-35	*Vaccinium vitis-idaea*	3
Vaccinium caespitosum	4	*Juniperus communis*	<1
Bryoids			
Cladonia mitis	10-15	*Stereocaulon tomentosum*	3-5
Peltigera aphthosa	<1	*Cladonia* spp.	3-10
Epiphytes			
Letharia vulpina			

Successional Status: advanced-mature
Related Vegetation Types: C9

C36: *Pinus contorta-Picea glauca/Salix glauca/Elymus innovatus*
(lodgepole pine-white spruce/willow/hairy wild rye)

Environment

Ecoregion: Lower Subalpine
Moisture Regime: mesic-subhygric
Soils: Eutric Brunisols
Slope: gentle-moderate
Aspect: various
Landform: fluvial

Characteristic Species (% cover)

Trees			
Pinus contorta	10-25	*Picea glauca*	5-20
Shrubs			
Salix glauca	15-30	*Betula glandulosa*	5-10
Ledum groenlandicum	5	*Shepherdia canadensis*	<5
Herbs-Dwarf Shrubs			
Elymus innovatus	10-25	*Linnaea borealis*	5
Fragaria virginiana	2-3	*Epilobium angustifolium*	2-3
Bryoids			
Hylocomium splendens	5-25	*Pleurozium schreberi*	10-20
Peltigera aphthosa	3-5		

Successional Status: intermediate
Related Vegetation Types: C37, O18

C37: *Picea glauca/Shepherdia canadensis/Hylocomium splendens*
(white spruce/buffaloberry/feathermoss)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: mesic
Soils: Regosolics, Eutric Brunisols

Slope: various
Aspect: northerly
Landform: fluvial, morainal

Characteristic Species (% cover)

Trees			
Picea glauca	20–50	*Pinus contorta*	<10
Shrubs			
Shepherdia canadensis	10–50	*Juniperus communis*	<10
Salix glauca	<10	*Rosa acicularis*	<10
Herbs–Dwarf Shrubs			
Elymus innovatus	1–35	*Arctostaphylos uva-ursi*	<5
Linnaea borealis	1–20	*Pyrola secunda*	<1
Fragaria virginiana	<1	*Equisetum scirpoides*	<1
Bryoids			
Hylocomium splendens	20–70	*Pleurozium schreberi*	5–15
Ptilium crista-castrensis	<5	*Peltigera aphthosa*	<5

Successional Status: mature
Related Vegetation Types: C2, C26, C27

OPEN FOREST VEGETATION TYPES

O2: *Pinus flexilis–Pseudotsuga menziesii/Juniperus* spp./*Arctostaphylos uva-ursi*
(limber pine–Douglas fir juniper/bearberry)

Environment

Ecoregion: Montane
Moisture Regime: xeric–subxeric
Soils: Regosolics

Slope: moderate–steep
Aspect: southerly
Landform: glacial

Characteristic Species (% cover)

Trees			
Pinus flexilis	5–40	*Pseudotsuga menziesii*	10–15
Shrubs			
Juniperus scopulorum	15–20	*Juniperus communis*	5–10
Potentilla fruticosa	<2		
Herbs–Dwarf Shrubs			
Arctostaphylos uva-ursi	20	*Artemisia frigida*	<5
Erigeron caespitosus	<4	*Anemone patens*	<3
Oxytropis sericea	<2		

Successional Status: mature
Related Vegetation Types: O5

O3: *Picea glauca/Potentilla fruticosa/Arctostaphylos uva-ursi*
(white spruce/shrubby cinquefoil/bearberry)

Environment

Ecoregion: Montane
Moisture Regime: subxeric–mesic
Soils: Regosolics

Slope: level–gentle
Aspect: various
Landform: fluvial

Characteristic Species (% cover)

Trees			
Picea glauca	5–20		
Shrubs			
Potentilla fruticosa	1–15	*Shepherdia canadensis*	1–10
Juniperus communis	<10		
Herbs–Dwarf Shrubs			
Arctostaphylos uva-ursi	5–35	*Elymus innovatus*	1–30
Fragaria virginiana	1–3		
Bryoids			
Thuidium abietinum	1–10	*Ditrichum flexicaule*	<3
Peltigera canina	<1		

Successional Status: intermediate–mature
Related Vegetation Types: O17

O4: *Picea engelmannii–Abies lasiocarpa–Pinus albicaulis–Pinus contorta*
(Engelmann spruce–subalpine fir–whitebark pine–lodgepole pine)

Environment

Ecoregion: Lower–Upper Subalpine
Moisture Regime: subxeric
Soils: Eutric and Dystric Brunisols, Regosolics

Slope: steep
Aspect: southerly
Landform: colluvial, morainal

Characteristic Species (% cover)

Trees			
Picea engelmannii	<20	*Abies lasiocarpa*	<20
Pinus albicaulis	<20	*Pinus contorta*	<20
Shrubs			
Juniperus communis	3–20	*Shepherdia canadensis*	<15
Herbs–Dwarf Shrubs			
Elymus innovatus	3–15	*Arctostaphylos uva-ursi*	3–25
Linnaea borealis	<10	*Zygadenus elegans*	<3
Fragaria virginiana	<10		

Successional Status: intermediate–mature
Related Vegetation Types: C3, O10

O5: *Pseudotsuga menziesii/Juniperus communis/Arctostaphylos uva-ursi*
(Douglas fir/juniper/bearberry)

Environment

Ecoregion: Montane
Moisture Regime: subxeric–xeric
Soils: Regosolics, Eutric Brunisols
Slope: moderate–steep
Aspect: southerly
Landform: glacial

Characteristic Species (% cover)

Trees			
Pseudotsuga menziesii	5–25	*Picea glauca*	<5
Shrubs			
Juniperus communis	5–15	*Pseudotsuga menziesii*	5–25
Rosa acicularis	<2	*Spiraea lucida*	≤1
Herbs–Dwarf Shrubs			
Arctostaphylos uva-ursi	5–40	*Senecio canus*	1–8
Agropyron spicatum	5–20	*Koeleria cristata*	<6
Galium boreale	≤2		

Successional Status: mature
Related Vegetation Types: C1, O2

O6: *Picea engelmannii–Abies lasiocarpa/Salix* spp./*Aulacomnium palustre*
(Engelmann spruce–subalpine fir/willow/ribbed bog moss)

Environment

Ecoregion: Lower–Upper Subalpine
Moisture Regime: hygric–hydric
Soils: Gleysolics, Organics
Slope: gentle
Aspect: various
Landform: fluvial

Characteristic Species (% cover)

Trees			
Picea engelmannii	3–15	*Abies lasiocarpa*	<5
Shrubs			
Salix glauca	5–20	*Salix barrattiana*	10–15
Betula glandulosa	<15	*Ledum groenlandicum*	<15
Potentilla fruticosa	1–10		
Herbs–Dwarf Shrubs			
Carex vaginata	5–30	*Carex aquatilis*	10–40
Equisetum arvense	1–15	*Pedicularis bracteosa*	<3
Equisetum variegatum	<2		
Bryoids			
Aulacomnium palustre	10–40	*Tomenthypnum nitens*	10–35

Successional Status: mature
Related Vegetation Types: O18, S1

O7: *Picea glauca–Picea mariana/Triglochin maritima–Carex* spp.
(spruce/arrowgrass–sedge)

Environment

Ecoregion: Montane
Slope: level–very gentle

Moisture Regime: hygric–subhydric
Soils: Gleysolics

Aspect: various
Landform: fluvial

Characteristic Species (% cover)

Trees			
Picea glauca	2–4	*Picea mariana*	10–15
Shrubs			
Potentilla fruticosa	3–5	*Salix* spp.	1–15
Betula pumila	<1		
Herbs–Dwarf Shrubs			
Triglochin maritima	<1	*Carex* spp.	2–10
Juncus balticus	<1	*Tofieldia glutinosa*	<1
Bryoids			
Tomenthypnum nitens	1–35	*Drepanocladus revolvens*	<1
Campylium stellatum	<1		

Successional Status: mature
Related Vegetation Types: O11

O9: *Picea engelmannii–Abies lasiocarpa/Valeriana sitchensis–Erigeron peregrinus*
(Engelmann spruce–subalpine fir/valerian–fleabane)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: mesic–subhygric
Soils: Eutric and Dystric Brunisols, Melanic Brunisols, Gleysolics

Slope: various
Aspect: various
Landform: morainal, fluvial

Characteristic Species (% cover)

Trees			
Picea engelmannii	5–20	*Abies lasiocarpa*	5–10
Shrubs			
Abies lasiocarpa	5–10	*Picea engelmannii*	1–5
Herbs–Dwarf Shrubs			
Valeriana sitchensis	5–15	*Erigeron peregrinus*	5–10
Trollius albiflorus	5–10	*Vaccinium scoparium*	5–15
Cassiope mertensiana	5–10	*Erythronium grandiflorum*	5–10
Artemisia norvegica	5–10		
Bryoids			
Dicranum scoparium	5–10	*Drepanocladus uncinatus*	5–10
Aulacomnium palustre	3–10	*Peltigera aphthosa*	≤1

Successional Status: mature
Related Vegetation Types: O10, H16

O10: *Picea engelmannii–Abies lasiocarpa/Phyllodoce glanduliflora–Cassiope mertensiana*
(Engelmann spruce–subalpine fir/heather)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: mesic
Soils: Eutric and Dystric Brunisols, Humo–Ferric Podzols
Slope: various
Aspect: northerly
Landform: morainal, colluvial

Characteristic Species (% cover)

Trees			
Picea engelmannii	<20	*Abies lasiocarpa*	<20
Shrubs			
Abies lasiocarpa	10–50	*Picea engelmannii*	5–10
Herbs–Dwarf Shrubs			
Phyllodoce glanduliflora	5–50	*Phyllodoce empetriformis*	5–50
Cassiope mertensiana	10–50	*Vaccinium scoparium*	5–25
Antennaria lanata	<10	*Pedicularis bracteosa*	<5
Bryoids			
Barbilophozia lycopodioides	5–50	*Dicranum scoparium*	5–25
Peltigera aphthosa	<5	*Cladonia ecmocyna*	<5
Cetraria islandica	<5		

Successional Status: mature
Related Vegetation Types: C23, C34, O9, L5

O11: *Picea* spp./*Ledum groenlandicum/Tomenthypnum nitens*
(spruce/Labrador tea/brown moss)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: hygric–subhygric
Soils: Gleysolics, Organics
Slope: level–very gentle
Aspect: various
Landform: glacial, glaciolacustrine

Characteristic Species (% cover)

Trees			
Picea spp.	5–15		
Shrubs			
Ledum groenlandicum	10–15	*Betula glandulosa*	5–15
Potentilla fruticosa	3	*Salix glauca*	3
Salix myrtillifolia	5		
Herbs–Dwarf Shrubs			
Carex aquatilis	10–20	*Carex vaginata*	1–3
Equisetum arvense	5–10	*Vaccinium vitis-idaea*	1–2
Bryoids			
Tomenthypnum nitens	20–25	*Aulacomnium palustre*	5–10
Sphagnum warnstorfii	3–5	*Sphagnum fuscum*	5–15

Successional Status: mature
Related Vegetation Types: O6

O12: *Picea engelmannii–Abies lasiocarpa/Salix vestita/Arctostaphylos rubra*
(Engelmann spruce–subalpine fir/rock willow/alpine bearberry)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: mesic–subhygric
Soils: Eutric Brunisols, Regosolics
Slope: moderate–steep
Aspect: northerly
Landform: colluvial, fluvial, morainal

Characteristic Species (% cover)

Trees			
Picea engelmannii	<15	*Abies lasiocarpa*	<10
Shrubs			
Salix vestita	10–35	*Abies lasiocarpa*	3–15
Herbs–Dwarf Shrubs			
Arctostaphylos rubra	3–15	*Dryas octopetala*	3–10
Bryoids			
Hylocomium splendens	3–15	*Dicranum scoparium*	2–10

Successional Status: mature
Related Vegetation Types: O14, S2

O14: *Picea engelmannii–Abies lasiocarpa/Salix vestita/Pedicularis bracteosa*
(Engelmann spruce–subalpine fir/rock willow/bracted lousewort)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: subhygric–hygric
Soils: Gleysolics
Slope: moderate–steep
Aspect: northerly
Landform: morainal, fluvial

Characteristic Species (% cover)

Trees			
Picea engelmannii	<20	*Abies lasiocarpa*	<10
Shrubs			
Salix vestita	5–50	*Abies lasiocarpa*	10–20
Herbs–Dwarf Shrubs			
Pedicularis bracteosa	1–5	*Polygonum viviparum*	<3
Erigeron peregrinus	1–3	*Vaccinium scoparium*	2–15
Anemone parviflora	<3		
Bryoids			
Pleurozium schreberi	5–15	*Barbilophozia* spp.	3–10
Aulacomnium palustre	10	*Peltigera aphthosa*	<5

Successional Status: mature
Related Vegetation Types: O12

O16: *Betula papyrifera/Betula occidentalis/Arctostaphylos uva-ursi*

(paper birch/bearberry)

Environment

Ecoregion: Montane
Moisture Regime: subxeric
Soils: Regosolics

Slope: moderate–steep
Aspect: southerly
Landform: eolian

Characteristic Species (% cover)

Trees			
Betula papyrifera	6		
Shrubs			
Betula occidentalis	9	*Juniperus communis*	3
Potentilla fruticosa			
Herbs–Dwarf Shrubs			
Arctostaphylos uva-ursi	40	*Elymus innovatus*	3
Aster conspicuus	2	*Carex concinna*	2
Zygadenus elegans	1	*Anemone multifida*	1
Carex scirpoidea	1		

Successional Status: intermediate–mature
Related Vegetation Types: O17

O17: *Picea glauca/Juniperus communis/Arctostaphylos uva-ursi*
(white spruce/juniper/bearberry)

Environment

Ecoregion: Lower Subalpine
Moisture Regime: subxeric–mesic
Soils: Eutric Brunisols, Regosolics

Slope: various
Aspect: southerly, westerly
Landform: colluvial, fluvial, morainal

Characteristic Species (% cover)

Trees			
Picea glauca	10–20		
Shrubs			
Juniperus communis	5–20	*Shepherdia canadensis*	3–15
Rosa acicularis	1–5		
Herbs–Dwarf Shrubs			
Arctostaphylos uva-ursi	10–25	*Elymus innovatus*	5–15
Linnaea borealis	3–5		
Bryoids			
Thuidium abietinum	2–5	*Ditrichum flexicaule*	<1
Tortula ruralis	<1	*Peltigera canina*	<1
Peltigera rufescens	<1		
Epiphytes			
Letharia vulpina		*Parmeliopsis ambigua*	
Cetraria pinastri			

Successional Status: intermediate–mature
Related Vegetation Types: O3

O18: *Picea engelmannii–Abies lasiocarpa/Salix glauca/Elymus innovatus*
(Engelmann spruce–subalpine fir/willow/hairy wild rye)

Environment

Ecoregion: Lower–Upper Subalpine
Moisture Regime: mesic
Soils: Eutric Brunisols, Regosolics
Slope: moderate–steep
Aspect: southerly, westerly
Landform: fluvial, colluvial

Characteristic Species (% cover)

Trees			
Picea engelmannii	5–20	*Abies lasiocarpa*	≤5
Shrubs			
Salix glauca	5–30	*Shepherdia canadensis*	≤2
Herbs–Dwarf Shrubs			
Elymus innovatus	10–55	*Arctostaphylos uva-ursi*	2–15
Hedysarum sulphurescens	5–25	*Hedysarum alpinum*	2–10
Bryoids			
Peltigera aphthosa	<1	*Drepanocladus uncinatus*	<1
Cladonia pyxidata	<1		

Successional Status: mature
Related Vegetation Types: C33

O19: *Picea engelmannii–Abies lasiocarpa/Dryas octopetala*
(Engelmann spruce–subalpine fir/mountain avens)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: mesic
Soils: Eutric and Melanic Brunisois
Slope: steep
Aspect: various
Landform: colluvial, morainal

Characteristic Species (% cover)

Trees			
Picea engelmannii	5–20	*Abies lasiocarpa*	5–15
Herbs–Dwarf Shrubs			
Dryas octopetala	15–45	*Salix arctica*	1–5
Carex spp.	1–5	*Arctostaphylos rubra*	1–3
Artemisia norvegica	1–2	*Arctostaphylos uva-ursi*	<5
Zygadenus elegans	1–2		
Bryoids			
Tortula ruralis	1–5	*Tortula norvegica*	<1
Thuidium abietinum	1–2	*Cetraria ericetorum*	<1
Cetraria islandica	<1		

Successional Status: mature
Related Vegetation Types: O10

SHRUB VEGETATION TYPES

S1: *Betula* spp.–*Potentilla fruticosa*/*Tomenthypnum nitens*
(dwarf birch–shrubby cinquefoil–willow/brown moss)

Environment

Ecoregion: Montane–Upper Subalpine
Moisture Regime: subhygric–hydric
Soils: Gleysolics, Organics
Slope: level–gentle
Aspect: various
Landform: fluvial, morainal

Characteristic Species (% cover)

Shrubs			
Betula spp.	5–20	*Potentilla fruticosa*	5–25
Salix glauca	10–40		
Herbs–Dwarf Shrubs			
Carex aquatilis	10–40	*Deschampsia caespitosa*	10–25
Rubus acaulis	<5	*Pedicularis groenlandica*	<3
Bryoids			
Tomenthypnum nitens	15–60	*Aulacomnium palustre*	<20
Drepanocladus revolvens	10–40	*Campylium stellatum*	<20

Successional Status: mature
Related Vegetation Types: S3, S4, S9, S10, S11

S2: *Abies lasiocarpa*–*Salix* spp./*Valeriana sitchensis*
(subalpine fir–willow)

Environment

Ecoregion: Lower–Upper Subalpine
Moisture Regime: mesic–subhygric
Soils: Regosolics, Eutric and Dystric Brunisols
Slope: steep
Aspect: various
Landform: colluvial

Characteristic Species (% cover)

Shrubs			
Abies lasiocarpa	10–70	*Salix vestita*	10–20
Salix glauca	5–30		
Herbs–Dwarf Shrubs			
Valeriana sitchensis	<15	*Epilobium angustifolium*	<10
Artemisia norvegica	<20	*Pedicularis bracteosa*	<12
Thalictrum occidentale	<15		
Bryoids			
Pleurozium schreberi	3–5	*Brachythecium* spp.	2–5
Barbilophozia spp.	2–5		

Successional Status: mature
Related Vegetation Types: S10, H5

S3: *Betula glandulosa–Potentilla fruticosa/Scirpus caespitosus/Drepanocladus revolvens*
(dwarf birch–shrubby cinquefoil/needlerush)

Environment

Ecoregion: Lower Subalpine
Moisture Regime: subhydric–hydric
Soils: Organics, Gleysolics

Slope: nearly level
Aspect: various
Landform: glacial, glaciolacustrine, fluvial

Characteristic Species (% cover)

Shrubs			
Betula glandulosa	2–15	*Potentilla fruticosa*	<1–15
Herbs–Dwarf Shrubs			
Scirpus caespitosus	20–80	*Pedicularis groenlandica*	1–5
Carex aquatilis	5–15	*Eriophorum angustifolium*	<1
Anemone parviflora	<1	*Antennaria lanata*	<1
Bryoids			
Drepanocladus revolvens	20–80	*Tomenthypnum nitens*	5–40
Campylium stellatum	1–30		

Successional Status: mature
Related Vegetation Types: S1

S4: *Salix* spp.–*Betula glandulosa/Erigeron peregrinus*
(willow–dwarf birch/fleabane)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: hygric–mesic
Soils: Gleysolics, Regosolics, Eutric Brunisols

Slope: level–moderate
Aspect: various
Landform: fluvial, morainal

Characteristic Species (% cover)

Shrubs			
Salix glauca	10–45	*Betula glandulosa*	10–50
Salix barrattiana	5–20		
Herbs–Dwarf Shrubs			
Erigeron peregrinus	3–10	*Fragaria virginiana*	1–10
Artemisia norvegica	1–5	*Potentilla diversifolia*	1–3
Achillea millefolium	<1	*Phleum alpinum*	<1
Trollius albiflorus	<1	*Valeriana sitchensis*	<1
Bryoids			
Aulacomnium palustre	5–30	*Drepanocladus uncinatus*	3–10
Tomenthypnum nitens	5–10	*Dicranum scoparium*	3–10
Peltigera canina	<1		

Successional Status: mature
Related Vegetation Types: S8, S10, S12

S6: *Salix scouleriana–Alnus crispa/Mertensia paniculata*
(willow–green alder/bluebell)

Environment

Ecoregion: Lower Subalpine
Moisture Regime: subhygric–hygric
Soils: Eutric Brunisols

Slope: moderate
Aspect: northerly
Landform: morainal

Characteristic Species (% cover)

Shrubs			
Salix scouleriana	10–60	*Alnus* spp.	10–80
Rosa acicularis	5–15	*Rubus strigosus*	7
Viburnum edule	3	*Lonicera involucrata*	1
Herbs–Dwarf Shrubs			
Mertensia paniculata	2	*Cornus canadensis*	5
Rubus pubescens	4	*Calamagrostis canadensis*	3
Galium triflorum	<1	*Epilobium angustifolium*	<1
Viola renifolia	<1	*Moneses uniflora*	<1

Successional Status: mature
Related Vegetation Types: none

S7: *Salix* spp./*Equisetum arvense*
(willow/horsetail)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: hygric
Soils: Gleysolics, Regosolics

Slope: level–gentle
Aspect: various
Landform: fluvial

Characteristic Species (% cover)

Shrubs			
Salix glauca	25–30	*Salix bebbiana*	10–25
Salix planifolia	<25	*Salix farrae*	10–15
Herbs–Dwarf Shrubs			
Equisetum arvense	1–25	*Fragaria virginiana*	<6
Achillea millefolium	<2	*Vicia americana*	<6
Taraxacum officinale	<1		
Bryoids			
Drepanocladus spp.	2–5		

Successional Status: early–intermediate
Related Vegetation Types: S11

S8: *Salix barrattiana/Potentilla diversifolia*
(willow/cinquefoil)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: subhygric–hygric
Soils: Gleysolics, Regosolics

Slope: gentle–moderate
Aspect: northerly, easterly
Landform: fluvial, morainal

Characteristic Species (% cover)

Shrubs			
Salix barrattiana	20–60	*Salix glauca*	5–20
Herbs–Dwarf Shrubs			
Potentilla diversifolia	1–5	*Trollius albiflorus*	3–15
Erigeron peregrinus	3–10	*Artemisia norvegica*	1–10
Polygonum viviparum	1–3	*Valeriana sitchensis*	1–2
Senecio triangularis	1–2	*Pedicularis bracteosa*	<1–2
Bryoids			
Aulacomnium palustre	1–30	*Tortula norvegica*	1–5
Bryum pseudotriquetrum	<1–5	*Brachythecium* spp.	<1

Successional Status: mature
Related Vegetation Types: S4, S10, S12

S9: *Betula glandulosa–Salix glauca/Kobresia myosuroides*
(dwarf birch–willow/kobresia)

Environment

Ecoregion: Lower–Upper Subalpine
Moisture Regime: mesic
Soils: Regosolics, Gleysolics, Brunisolics
Slope: level–gentle
Aspect: various
Landform: fluvial

Characteristic Species (% cover)

Shrubs			
Betula glandulosa	15–50	*Salix glauca*	10–30
Potentilla fruticosa	5–20		
Herbs–Dwarf Shrubs			
Kobresia myosuroides	15–50	*Achillea millefolium*	<2
Elymus innovatus	2–15	*Fragaria virginiana*	2–8
Bryoids			
Tortula ruralis	<5	*Cetraria ericetorum*	<1
Cladonia pyxidata	<1	*Peltigera rufescens*	<1

Successional Status: mature
Related Vegetation Types: S1, S4, S10, S11

S10: *Salix glauca–Betula glandulosa–Potentilla fruticosa*
(willow–dwarf birch–shrubby cinquefoil)

Environment

Ecoregion: Lower–Upper Subalpine
Moisture Regime: mesic–subxeric
Soils: Brunisols, Regosolics
Slope: moderate–steep
Aspect: southerly, westerly
Landform: colluvial, fluvial, morainal

Characteristic Species (% cover)

Shrubs			
Salix glauca	15–40	*Betula glandulosa*	10–35
Potentilla fruticosa	1–3	*Juniperus communis*	1–10
Herbs–Dwarf Shrubs			
Arctostaphylos uva-ursi	10–20	*Epilobium angustifolium*	1–5
Elymus innovatus	10–20	*Hedysarum sulphurescens*	1–5
Fragaria virginiana	2–5		
Bryoids			
Tortula ruralis	1–5	*Peltigera* spp.	<1

Successional Status: mature
Related Vegetation Types: S4, S8, S11, S12

S11: *Salix glauca/Danthonia intermedia*
(willow/timber oatgrass)

Environment

Ecoregion: Lower–Upper Subalpine
Moisture Regime: hygric–mesic
Soils: Gleysolics, Regosolics, Brunisolics

Slope: gentle
Aspect: various
Landform: fluvial

Characteristic Species (% cover)

Shrubs			
Salix glauca	10–45	*Betula glandulosa*	5–15
Potentilla fruticosa	5–20		
Herbs–Dwarf Shrubs			
Danthonia intermedia	10–40	*Fragaria virginiana*	5–20
Phleum alpinum	1–5	*Potentilla diversifolia*	1–3
Trisetum spicatum	1–3	*Achillea millefolium*	1–2
Valeriana sitchensis	1		
Bryoids			
Tortula ruralis	2–5	*Aulacomnium palustre*	5–20
Tortula norvegica	2–15	*Polytrichum juniperinum*	3–15

Successional Status: mature
Related Vegetation Types: S1, S4, S9, S10, S12

S12: *Salix glauca/Elymus innovatus*
(willow/hairy wild rye)

Environment

Ecoregion: Lower–Upper Subalpine
Moisture Regime: mesic–subhygric
Soils: Eutric Brunisols, Regosolics

Slope: various
Aspect: southerly, westerly
Landform: fluvial, colluvial, morainal

Characteristic Species (% cover)

Shrubs			
Salix glauca	30–60	*Betula glandulosa*	5–15

Herbs–Dwarf Shrubs			
Elymus innovatus	20–40	*Fragaria virginiana*	1–5
Achillea millefolium	1	*Astragalus alpinus*	1–3
Delphinium glaucum	1–3	*Epilobium angustifolium*	1–3
Equisetum scirpoides	1–3	*Potentilla diversifolia*	1–5
Poa spp.	1–5		
Bryoids			
Tortula ruralis	<1–5	*Tortula norvegica*	<1
Peltigera rufescens	<1	*Cladonia pyxidata*	<1
Ceratodon purpureus	<1		

Successional Status: mature
Related Vegetation Types: S4, S8, S10, S11

LOW SHRUB-HERB VEGETATION TYPES

L1: *Potentilla fruticosa/Arctostaphylos uva-ursi–Galium boreale*
(shrubby cinquefoil/bearberry–northern bedstraw)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: subxeric–xeric
Soils: Regosolics
Slope: steep
Aspect: southerly
Landform: colluvial, eolian, glacial

Characteristic Species (% cover)

Shrubs			
Potentilla fruticosa	<15	*Juniperus communis*	<5
Herbs–Dwarf Shrubs			
Arctostaphylos uva-ursi	10–55	*Galium boreale*	<3
Artemisia frigida	<5	*Anemone multifida*	<2
Koeleria cristata	<5	*Campanula rotundifolia*	<1
Elymus innovatus	<15	*Agropyron spicatum*	<10

Successional Status: mature
Related Vegetation Types: C3, H14

L2: *Juniperus communis–Salix glauca*
(juniper–willow)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: subxeric
Soils: Regosolics, Eutric Brunisols
Slope: steep
Aspect: southerly
Landform: colluvial

Characteristic Species (% cover)

Shrubs			
Juniperus communis	10–25	*Salix glauca*	10–25
Potentilla fruticosa	1–5	*Shepherdia canadensis*	2–5
Rosa acicularis	1–2		

Herbs-Dwarf Shrubs			
Arctostaphylos uva-ursi	10-25	*Fragaria virginiana*	1-3
Elymus innovatus	1-3	*Epilobium angustifolium*	1-3
Achillea millefolium	<1	*Saxifraga bronchialis*	<1
Trisetum spicatum	<1	*Zygadenus elegans*	<1
Linnaea borealis	<1		

Successional Status: mature
Related Vegetation Types: S10

L4: *Cassiope tetragona-Dryas octopetala-Salix nivalis*
(white mountain heather-mountain avens-snow willow)

Environment

Ecoregion: Alpine
Moisture Regime: mesic-subhygric
Soils: Brunisols, Regosolics
Slope: gentle-steep
Aspect: northerly
Landform: morainal, colluvial

Characteristic Species (% cover)

Herbs-Dwarf Shrubs			
Cassiope tetragona	10-50	*Phyllodoce glanduliflora*	<15
Dryas octopetala	10-35	*Salix nivalis*	10-35
Polygonum viviparum	<1	*Silene acaulis*	<5
Potentilla diversifolia	1	*Salix arctica*	<15
Bryoids			
Dicranum scoparium	<2	*Cetraria islandica*	<5
Cetraria nivalis	<3	*Stereocaulon alpinum*	<3

Successional Status: mature
Related Vegetation Types: C23, O10, L5, H1

L5: *Phyllodoce glanduliflora-Cassiope mertensiana-Antennaria lanata*
(heather-everlasting)

Environment

Ecoregion: Alpine
Moisture Regime: mesic
Soils: Brunisolics, Humo-Ferric Podzols
Slope: various
Aspect: various
Landform: morainal, residual

Characteristic Species (% cover)

Herbs-Dwarf Shrubs			
Phyllodoce glanduliflora	10-50	*Cassiope mertensiana*	10-70
Cassiope tetragona	<10	*Antennaria lanata*	2-15
Salix arctica	<15	*Sibbaldia procumbens*	<5
Erigeron peregrinus	<2	*Potentilla diversifolia*	<1
Luzula wahlenbergii	1	*Artemisia norvegica*	<5
Bryoids			
Dicranum scoparium	<10	*Polytrichum juniperinum*	<3
Cladonia ecmocyna	<3	*Cetraria islandica*	<2

Successional Status: mature
Related Vegetation Types: C23, O10, L4

L6: *Juniperus horizontalis–Agropyron dasystachyum–Carex scirpoidea*
(creeping juniper–northern wheatgrass–sedge)

Environment

Ecoregion: Montane
Moisture Regime: subxeric
Soils: Regosolics

Slope: various
Aspect: southerly
Landform: eolian

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Juniperus horizontalis	20–30	*Agropyron dasystachyum*	5–10
Carex scirpoidea	5–30	*Potentilla fruticosa*	<5
Hedysarum mackenzii	<5	*Arctostaphylos uva-ursi*	<5
Koeleria cristata	<5	*Senecio cymbalarioides*	<1
Carex richardsonii	<1		

Successional Status: mature
Related Vegetation Types: H6, H7

L7: *Salix arctica–Potentilla diversifolia*
(arctic willow–cinquefoil)

Environment

Ecoregion: Upper Subalpine–Alpine
Moisture Regime: mesic–subhygric
Soils: Regosolics, Gleysolics, Brunisolics

Slope: various
Aspect: various
Landform: morainal, fluvial

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Salix arctica	10–35	*Potentilla diversifolia*	1–3
Antennaria lanata	5–20	*Phyllodoce glanduliflora*	1–5
Salix nivalis	1–5	*Castilleja occidentalis*	1–3
Erigeron peregrinus	<1	*Poa alpina*	<1
Polygonum viviparum	<1	*Sibbaldia procumbens*	<1
Artemisia norvegica	<1		
Bryoids			
Cladonia pyxidata	<1	*Cetraria ericetorum*	<1
Cetraria cucullata	<1		

Successional Status: mature
Related Vegetation Types: H2, H16

HERB-DWARF SHRUB VEGETATION TYPES

H1: *Dryas octopetala–Salix nivalis–Silene acaulis*
(mountain avens–snow willow–moss campion)

Environment

Ecoregion: Alpine
Moisture Regime: mesic–subxeric
Soils: Regosolics, Brunisolics

Slope: various
Aspect: southerly, westerly
Landform: morainal, colluvial

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Dryas octopetala	20–50	*Salix nivalis*	1–10
Silene acaulis	1–3	*Oxytropis podocarpa*	<3
Polygonum viviparum	1–2	*Selaginella densa*	<1
Poa alpina	<1	*Potentilla diversifolia*	<1
Salix arctica	<1	*Castilleja occidentalis*	<1
Carex nardina	<1	*Saxifraga oppositifolia*	<1
Bryoids			
Cetraria nivalis	<1	*Cetraria cucullata*	<1

Successional Status: mature
Related Vegetation Types: L4, L5, L7, H2, H4

H2: *Carex nigricans–Antennaria lanata*
(black alpine sedge–everlasting)

Environment

Ecoregion: Alpine
Moisture Regime: mesic–subhygric
Soils: Dystric and Sombric Brunisols, Humo–Ferric Podzols
Slope: various
Aspect: various
Landform: morainal, residual

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Carex nigricans	10–90	*Antennaria lanata*	5–35
Luzula wahlenbergii	<5	*Sibbaldia procumbens*	<5
Veronica alpina	<3	*Juncus drummondii*	<5
Poa alpina	<10	*Ranunculus eschscholtzii*	<5
Salix arctica	<12	*Phyllodoce glanduliflora*	<10
Bryoids			
Pogonatum alpinum	2–20	*Tortula norvegica*	<2
Cladonia ecmocyna	<5		

Successional Status: mature
Related Vegetation Types: L4, L5, L7, H1

H3: *Carex scirpoidea–Saxifraga aizoides*
(sedge–saxifrage)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: hygric
Soils: Gleysolics
Slope: level
Aspect: various
Landform: fluvial

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Carex scirpoidea	1–5	*Saxifraga aizoides*	1–5
Anemone parviflora	1–3	*Tofieldia pusilla*	<3
Polygonum viviparum	<1	*Equisetum variegatum*	<1
Castilleja occidentalis	<1	*Dryas integrifolia*	<1
Arctostaphylos rubra	<1	*Pinguicula vulgaris*	<1
Potentilla fruticosa	<1	*Saxifraga* sp.	<1

Successional Status: early–intermediate
Related Vegetation Types: S7

H4: *Dryas octopetala–Kobresia myosuroides–Arctostaphylos uva-ursi*
(mountain avens–kobresia–bearberry)

Environment

Ecoregion: Upper Subalpine–Alpine
Moisture Regime: subxeric–mesic
Soils: Melanic and Eutric Brunisols, Humic Regosolics
Slope: moderate–steep
Aspect: southerly
Landform: morainal, colluvial

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Dryas octopetala	10–35	*Arctostaphylos uva-ursi*	5–30
Kobresia myosuroides	15–40	*Polygonum viviparum*	<5
Oxytropis podocarpa	<15	*Androsace chamaejasme*	<3
Silene acaulis	<2		
Bryoids			
Cetraria nivalis	<10	*Cetraria cucullata*	<10

Successional Status: mature
Related Vegetation Types: H1, H5, H14

H5: *Elymus innovatus–Fragaria virginiana–Epilobium angustifolium*
(hairy wild rye–wild strawberry–fireweed)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: mesic
Soils: Melanic Brunisols, Humic Regosols
Slope: steep
Aspect: southerly
Landform: colluvial

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Elymus innovatus	15–55	*Fragaria virginiana*	1–10
Myosotis alpestris	<10	*Epilobium angustifolium*	<10
Zygadenus elegans	<8	*Achillea millefolium*	<5
Salix spp.	<5	*Rosa acicularis*	<5

Successional Status: mature
Related Vegetation Types: H6, H7, H14, H16, S2

H6: *Koeleria cristata–Artemisia frigida–Linum lewisii*
(junegrass–pasture sage–wild blue flax)

Environment

Ecoregion: Montane
Moisture Regime: subxeric–xeric
Soils: Regosolics, Eutric Brunisols
Slope: level–moderate
Aspect: southerly
Landform: fluvial, glaciofluvial, eolian

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Koeleria cristata	15–30	*Artemisia frigida*	1–20
Linum lewisii	1–10	*Antennaria nitida*	1–10
Galium boreale	<5	*Senecio cymbalarioides*	1–5
Gaillardia aristata	<5		
Bryoids			
Tortula ruralis	<3		

Successional Status: mature
Related Vegetation Types: H7, H13, H14

H7: *Agropyron dasystachyum–Artemisia frigida*
(wheatgrass–pasture sage)

Environment

Ecoregion: Montane
Moisture Regime: xeric
Soils: Eutric Brunisols, Regosolics
Slope: steep
Aspect: southerly
Landform: colluvial, glacial, fluvial

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Agropyron dasystachyum	5–50	*Artemisia frigida*	1–10
Koeleria cristata	2–10	*Achillea millefolium*	<5

Successional Status: mature
Related Vegetation Types: H6, H13, H14

H8: *Dryas drummondii–Epilobium latifolium*
(yellow dryad–willow herb)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: subxeric–subhygric
Soils: Regosolics
Slope: gentle
Aspect: various
Landform: fluvial, glaciofluvial, morainal

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Dryas drummondii	25–80	*Shepherdia canadensis*	<10
Salix brachycarpa	<15	*Arctostaphylos uva-ursi*	<5
Epilobium latifolium	<2		

Bryoids			
Drepanocladus uncinatus	<3	*Tortula norvegica*	<10

Successional Status: early
Related Vegetation Types: O3, S7, H3

H9: *Caltha leptosepala–Trollius albiflorus*
(mountain marigold–globeflower)

Environment

Ecoregion: Upper Subalpine–Alpine
Moisture Regime: subhygric–hygric
Soils: Gleysolics

Slope: gentle–moderate
Aspect: northerly, easterly
Landform: fluvial, morainal

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Caltha leptosepala	10–25	*Trollius albiflorus*	15–40
Carex nigricans	5–20	*Salix arctica*	5–10
Senecio triangularis	<10	*Erigeron peregrinus*	<10
Antennaria lanata	<10	*Pedicularis bracteosa*	<5
Polygonum viviparum	<5	*Valeriana sitchensis*	<5
Bryoids			
Aulacomnium palustre	10–50	*Campylium stellatum*	<10

Successional Status: mature
Related Vegetation Types: H2, H10, H16

H10: *Eriophorum angustifolium–Drepanocladus* spp.
(cottongrass/moss)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: hydric
Soils: Gleysolics, Organics

Slope: gentle
Aspect: various
Landform: fluvial, morainal

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Eriophorum angustifolium	20–60	*Caltha leptosepala*	variable
Carex nigricans	var.	*Pedicularis groenlandica*	variable
Scirpus caespitosus	var.		
Bryoids			
Drepanocladus exannulatus	70–80	*Drepanocladus revolvens*	variable
Calliergon sarmentosum	var.	*Paludella squarrosa*	variable

Successional Status: mature
Related Vegetation Types: H9, H16

H11: *Carex aquatilis–Carex rostrata*
(water sedge–beaked sedge)

Environment

Ecoregion: Montane–Upper Subalpine
Moisture Regime: hydric–subhydric
Soils: Organics, Gleysolics

Slope: level
Aspect: level
Landform: fluvial, morainal

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Carex aquatilis	15–70	*Carex rostrata*	10–60
Equisetum fluviatile	20–55	*Utricularia intermedia*	<4
Lemna minor	<1		
Bryoids			
Drepanocladus revolvens	10–55	*Tomenthypnum nitens*	<35
Campylium stellatum	<15	*Bryum pseudotriquetrum*	<10

Successional Status: mature
Related Vegetation Types: S1, S7

H12: Saxicolous lichen

Environment

Ecoregion: Alpine
Moisture Regime: subxeric–xeric
Soils: Regosolics, nonsoil

Slope: various
Aspect: various
Landform: colluvial, bedrock

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Silene acaulis	<1	*Saxifraga oppositifolia*	<1
Selaginella densa	<1	*Oxytropis podocarpa*	<1
Draba incerta	<1	*Salix nivalis*	<1
Bryoids			
Xanthoria elegans	<1	*Rhizocarpon geographicum*	<1
Cetraria tilesii	<1	*Sporastatia testudinea*	<1
Cetraria nivalis	<1	*Acarospora chlorophana*	<1
Cladonia pyxidata	<1	*Dactylina ramulosa*	<1

Successional Status: mature
Related Vegetation Types: H1

H13: *Stipa richardsonii–Koeleria cristata–Antennaria nitida*
(Richardson needlegrass–junegrass–everlasting)

Environment

Ecoregion: Montane
Moisture Regime: subxeric–xeric
Soils: Regosolics, Eutric Brunisols

Slope: level–gentle
Aspect: southerly
Landform: glaciofluvial, fluvial, colluvial

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Stipa richardsonii	5–20	*Koeleria cristata*	2–10
Antennaria nitida	<8	*Anemone multifida*	<5
Selaginella densa	5	*Penstemon confertus*	<3
Galium boreale	<2	*Festuca scabrella*	<1

Successional Status: mature
Related Vegetation Types: H6, H7, H14

H14: *Elymus innovatus–Koeleria cristata–Arctostaphylos uva-ursi*
(hairy wild rye–junegrass–bearberry)

Environment

Ecoregion: Lower–Upper Subalpine
Moisture Regime: subxeric
Soils: Melanic and Eutric Brunisols

Slope: steep
Aspect: southerly
Landform: colluvial, morainal

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Elymus innovatus	5–50	*Hedysarum sulphurescens*	5–15
Koeleria cristata	5–35	*Arctostaphylos uva-ursi*	5–20
Bromus pumpellianus	1–10	*Achillea millefolium*	1–2
Fragaria virginiana	<10	*Anemone multifida*	<10
Cerastium arvense	<10	*Oxytropis splendens*	1
Myosotis alpestris	1–5	*Campanula rotundifolia*	<3
Antennaria nitida	1–2	*Poa* spp.	
Bryoids			
Tortula ruralis	<5		

Successional Status: mature
Related Vegetation Types: H4, H5, H6, H7, H13

H15: *Dryas integrifolia–Carex rupestris*
(mountain avens–curly sedge)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: subhygric
Soils: Eutric Brunisols, Regosolics

Slope: steep
Aspect: easterly
Landform: morainal

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Dryas integrifolia	10	*Carex rupestris*	20
Carex scirpoidea	3	*Carex albo-nigra*	3
Cassiope tetragona	3	*Ledum groenlandicum*	2
Arctostaphylos rubra	1		
Bryoids			
Cetraria sp.	<1		

Successional Status: mature
Related Vegetation Types: H1

H16: *Erigeron peregrinus–Valeriana sitchensis*
(fleabane–valerian)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: subhygric–mesic
Soils: Dystric Brunisols, Gleysolics, Regosolics

Slope: various
Aspect: various
Landform: fluvial, morainal

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Erigeron peregrinus	5–20	*Valeriana sitchensis*	5–20
Trollius albiflorus	5–20	*Anemone occidentalis*	5–15
Senecio triangularis	1–10	*Antennaria lanata*	1–5
Artemisia norvegica	1–5	*Pedicularis bracteosa*	<1–3
Salix arctica	1–5	*Potentilla diversifolia*	<1–2
Carex nigricans	<1	*Sibbaldia procumbens*	<1
Phleum alpinum	<1		
Bryoids			
Tortula ruralis	<15	*Pseudoleskea radicosa*	<15

Successional Status: mature
Related Vegetation Types: L7, H2, H9

H19: *Agropyron spicatum–Elymus innovatus–Aster conspicuus*
(bluebunch wheatgrass–hairy wild rye–showy aster)

Environment

Ecoregion: Montane–Lower Subalpine
Moisture Regime: xeric
Soils: Regosolics

Slope: steep
Aspect: southerly
Landform: colluvial, glacial

Characteristic Species (% cover)

Herbs–Dwarf Shrubs			
Agropyron spicatum	15–30	*Elymus innovatus*	10–30
Koeleria cristata	3–10	*Aster conspicuus*	3–5
Oxytropis splendens	<8	*Antennaria nitida*	<2
Cerastium arvense	<2		

Successional Status: mature
Related Vegetation Types: H4, H5, H6, H7, H13, H14

H20: *Saxifraga bronchialis–Elymus innovatus*
(spotted saxifrage–hairy wild rye)

Environment

Ecoregion: Upper Subalpine
Moisture Regime: subxeric–xeric
Soils: Regosolics

Slope: steep
Aspect: southerly
Landform: colluvial

Characteristic Species (% cover)

(cover is variable for all species, with total cover usually <50%)

Herbs--Dwarf Shrubs

Saxifraga bronchialis
Potentilla nivea
Festuca saximontana
Elymus innovatus
Achillea millefolium
Zygadenus elegans

Bryoids

Tortula ruralis

Successional Status: mature
Related Vegetation Types: H12

KEY TO VEGETATION TYPES

USE OF THE KEY

The term *dominant* (species with the highest % cover) is used in the key, but *abundant* can usually be substituted. Occasionally, species other than those in the key leads may be dominant. In such cases, use the species in the key leads which is most abundant. For example, in a *Pinus contorta/Shepherdia canadensis* closed forest (lead 8) *Elymus innovatus* (35%) may be dominant with *Linnaea borealis* (5%), *Aster conspicuus* (2%) and *Vaccinium scoparium* (25%). *Elymus innovatus* is dominant but not in the key leads. Therefore, use the most abundant species which is in the leads, which is *Vaccinium scoparium* and the stand keys to C18.

The following general cover value terms are used but should not be rigidly interpreted: sparse <15%, moderate 15–50%, and dense >50%. Often the cover of a species relative to other species in the stand is a better guide to its significance than the absolute cover values. Polychotomous leads have been used to save space and simplify the key. Alternative leads are grouped to minimize confusion.

Not all stands will key to a v.t.; intermediates occur and heterogeneous stands may be virtually unclassifiable, although their affinities may be apparent. The descriptions contain additional information and comments on related v.t.s which will help better place the stand in question. The key is only an aid to classification. Always consult the v.t. description to validate the determination.

KEY TO PHYSIOGNOMIC GROUPS

1a. Vegetation with trees $\geq$ 5m tall and tree cover >5 % 2
1b. Vegetation without trees $\geq$5m tall or tree cover <5 % 3
2a. Distance between tree crowns < 2X crown width, total tree cover usually >20% (some Open Forest stands with 15–20% tree cover may key here) ..... Closed Forest(C), I
2b. Distance between tree crowns 2–5X crown width, total tree cover usually $\leq$20%, (some sparse Closed Forest stands with <20% cover may key here) ..... Open Forest(O), II
3a. Vegetation dominated by shrubs $\geq$0.5–5m tall ..... Shrub(S), III
3b. Vegetation dominated by plants $\leq$0.5m tall 4
4a. Vegetation dominated by low shrubs (0.1–0.5m tall) and herbs ..... Low Shrub(L), IV
4b. Vegetation dominated by dwarf shrubs (<0.1m tall) or herbs ..... Herb–Dwarf Shrub(H), V

I. KEY TO CLOSED FOREST VEGETATION TYPES

1a.	Dominant trees broad-leaved	2
1b.	Dominant trees needle-leaved	5
2a.	Dominant tree *Populus tremuloides*	3
2b.	Dominant tree *Populus balsamifera*	4
3a.	*Lathyrus ochroleucus* and *Galium boreale* > *Aster conspicuus*, landform fluvial	C16
3b.	*Aster conspicuus* > *Lathyrus ochroleucus* and *Galium boreale*, landform colluvial	C22
4a.	*Shepherdia canadensis* and *Elymus innovatus* dominant, site mesic	C17
4b.	*Shepherdia canadensis* not dominant, *Equisetum* spp. dominant herbs, site hygric to subhygric	C28
5a.	Dominant tree *Larix lyallii*, occasionally codominant with *Abies lasiocarpa* (some stands may have open canopy)	C23
5b.	Dominant tree *Pseudotsuga menziesii* (if codominant with *Picea glauca* see C5)	C1
5c.	Dominant tree *Picea mariana*, *Pinus contorta* may be codominant	C8
5d.	Dominant trees *Picea engelmannii* and *Pinus albicaulis*	C12
5e.	Dominant tree *Pinus contorta*, *Picea* spp. may be codominant	6
5f.	Dominant tree *Picea* spp., *Abies lasiocarpa* may be codominant	11
6a.	Dominant shrub *Menziesia glabella*	C20
6b.	Dominant shrub *Alnus crispa*	C10
6c.	Dominant shrub *Salix glauca*	C36
6d.	Dominant shrub *Ledum groenlandicum*	C29
6e.	Dominant shrub *Juniperus communis*	C3
6f.	Dominant shrub *Shepherdia canadensis*	7
6g.	Shrub layer sparse, may have well developed dwarf shrub layer	9
7a.	*Aster conspicuus* 10–20%, site mesic	C6
7b.	*Aster conspicuus* <10%, site various	8
8a.	Dominant dwarf shrub *Vaccinium scoparium*	C18
8b.	Dominant dwarf shrub *Linnaea borealis*	C19
9a.	Herb-dwarf shrub layer sparse, bryoid layer well developed with *Hylocomium splendens* and *Pleurozium schreberi* dominant, site mesic	C11
9b.	Herb-dwarf shrub layer moderate to dense, sites mesic or subxeric	10
10a.	*Vaccinium caespitosum* dominant dwarf shrub, *Cladonia* spp. <25%, site mesic to subxeric	C9
10b.	*Empetrum nigrum* dominant dwarf shrub, *Cladonia* spp. >25%, site subxeric	C35
10c.	*Juniperus communis* and *Arctostaphylos uva-ursi* dominant dwarf shrubs, site subxeric	C3
11a.	Herb-dwarf shrub layer dominated by *Equisetum* spp.	12
11b.	Herb-dwarf shrub layer not dominated by *Equisetum* spp.	13
12a.	Shrub layer dense, dominated by *Rosa acicularis*, *Arnica cordifolia*, *Elymus innovatus* and *Mertensia paniculata* usually absent, Montane, site subhygric to hygric, *Picea* usually *Picea glauca*	C4
12b.	Shrub layer sparse, *Rosa acicularis* usually absent, *Arnica cordifolia*, *Elymus innovatus* and *Mertensia paniculata* usually present, Lower Subalpine, site mesic to subhygric, *Picea* usually *Picea engelmannii*	C32
13a.	Shrub layer dominated by *Rosa acicularis*, Jasper only	C27
13b.	Shrub layer dominated by *Menziesia glabella*	C14

13c Shrub layer dominated by *Vaccinium membranaceum* (or *Rhododendron albiflorum*) C21
13d Shrub layer dominated by *Salix vestita*, *Cassiope tetragona* present C24

13e Shrub layer dominated by *Ledum groenlandicum*, *Empetrum nigrum* usually present C30
13f Shrub layer dominated by *Shepherdia canadensis* 14
13g Shrub layer sparse 15
14a *Thuidium abietinum* dominant bryophyte C26
14b *Hylocomium splendens* dominant bryophyte C37
15a *Thuidium abietinum* dominant bryophyte, Jasper only C2
15b *Thuidium abietinum* not dominant bryophyte, both Banff and Jasper 16
16a *Vaccinium membranaceum* dominant dwarf shrub, *Barbilophozia lycopodioides* dominant bryophyte C21
16b *Vaccinium membranaceum* not dominant dwarf shrub, *Hylocomium splendens* (occasionally *Pleurozium schreberi* or *Dicranum* spp.) dominant bryophyte 17
17a Herb-dwarf shrub layer cover <15%, *Vaccinium scoparium* usually absent, Lower Subalpine C13
17b Herb-dwarf shrub layer cover >15%, *Vaccinium scoparium* usually present, Lower or Upper Subalpine 18
18a Herb-dwarf shrub layer dominated by *Phyllodoce glanduliflora* (or sometimes *Phyllodoce empetriformis*), herb cover low, Upper Subalpine C34
18b Herb-dwarf shrub layer dominated by *Elymus innovatus*, *Arnica cordifolia* and *Linnaea borealis*, herb cover high, Lower Subalpine C31
18c Herb-dwarf shrub layer dominated by *Vaccinium scoparium*, herb cover variable, Upper Subalpine C15

II KEY TO OPEN FOREST TYPES

1a Tree layer dominated by *Pinus flexilis*, often with *Pseudotsuga menziesii* O2
1b Tree layer dominated by *Pseudotsuga menziesii* O5
1c Tree layer dominated by mixture of *Picea* spp., *Abies lasiocarpa*, *Pinus albicaulis* and *Pinus contorta*; *Pseudotsuga menziesii* may be present at lower altitudes; usually on steep, colluvial, subxeric site (some open C35 may key here) O4
1d Tree layer dominated by *Betula* spp. O16
1e Tree layer dominated by *Picea glauca* and *Picea mariana* O7
1f Tree layer dominated by *Pinus contorta* with prominent *Juniperus communis* and *Arctostaphylos uva-ursi* in understory ..... open variant of C3
1g Tree layer dominated by *Picea glauca* or *Picea engelmannii*, *Abies lasiocarpa* may be codominant 2
2a *Ledum groenlandicum* dominant shrub O11
2b *Salix* spp. dominant shrub 3
2c *Potentilla fruticosa* dominant shrub O3
2d *Juniperus communis* dominant shrub O17
2e Shrub layer sparse or dominated by tree regeneration 6
3a *Salix vestita* dominant shrub 4
3b Dominant shrub *Salix* spp. other than *Salix vestita* 5
4a *Arctostaphylos rubra* dominant in herb-dwarf shrub layer O12
4b *Pedicularis bracteosa* dominant in herb-dwarf shrub layer O14
5a *Elymus innovatus* dominant herb, site mesic O18
5b *Carex* spp. dominant herb, site hygric to hydric O6

6a. Herb–dwarf shrub layer dominated by *Dryas octopetala* O19
6b. Herb–dwarf shrub layer dominated by *Phyllodoce glanduliflora*, *Cassiope mertensiana* or other ericaceous dwarf shrubs O10
6c. Herb–dwarf shrub layer dominated by *Valeriana sitchensis*, *Erigeron peregrinus* or other herbs O9

III. KEY TO SHRUB VEGETATION TYPES

1a. *Abies lasiocarpa* (or occasionally *Picea engelmannii*) dominant shrub, snow avalanche path S2
1b. *Salix scouleriana* and *Alnus spp.* dominant shrubs, Jasper S6
1c. *Salix barrattiana* dominant shrub S8
1d. Various *Salix* spp., *Betula glandulosa* or *Betula pumila* dominant 2
  2a. *Scirpus caespitosus* dominant herb S3
  2b. *Kobresia myosuroides* dominant herb S9
  2c. *Danthonia intermedia* dominant herb S11
  2d. *Equisetum arvense* dominant herb S7
  2e. None of the above 3
3a. *Potentilla fruticosa* usually present 4
3b. *Potentilla fruticosa* usually absent 5
  4a. Bryoid cover dense, *Tomenthypnum nitens* present, *Arctostaphylos uva-ursi* usually hydric, level to gentle slope S1
  4b. Bryoid cover sparse, *Tomenthypnum nitens* absent, *Arctostaphylos uva-ursi* usually present, site mesic to subxeric, moderate to steep slope S10
5a. *Elymus innovatus* cover $\geq$10%, *Salix barrattiana* usually absent S12
5b. *Elymus innovatus* cover <10%, *Salix barrattiana* usually present (5–20%) S4

IV. KEY TO LOW SHRUB–HERB VEGETATION TYPES

Dominant low shrub *Potentilla fruticosa* L1
Dominant low shrubs *Juniperus communis* and *Salix glauca*, snow avalanche path L2
Dominant low shrub *Cassiope tetragona*, snowbed L4
Dominant low shrubs *Phyllodoce glanduliflora* and *Cassiope mertensiana* L5
Dominant low shrub *Juniperus horizontalis* L6
Dominant low shrub *Salix arctica* L7

V. KEY TO HERB–DWARF SHRUB VEGETATION TYPES

1a. *Dryas* spp. dominant or codominant 2
1b. *Dryas* spp. not dominant 4
  2a. *Dryas drummondii* dominant H8
  2b. *Dryas integrifolia* dominant, *Carex rupestris* codominant, Jasper only H15
  2c. *Dryas octopetala* dominant, may contain *Dryas integrifolia* but *Carex rupestris* not codominant, see v.t. description for other differences. 3
3a. *Kobresia myosuroides*, *Arctostaphylos uva-ursi* codominant H4
3b. *Salix nivalis*, *Silene acaulis* codominant H1
  4a. Elevation <1700 m, subxeric to xeric grasslands 5

	4b.	Elevation mostly >1700 m, not subxeric to xeric grasslands	8
5a.	*Agropyron* spp. dominant		6
5b.	*Agropyron* spp. not dominant		7
	6a.	*Agropyron dasystachyum* dominant, *Artemisia frigida* codominant	H7
	6b.	*Agropyron spicatum* usually dominant, *Elymus innovatus* often codominant	H19
7a.	*Koeleria cristata* dominant, *Artemisia frigida* codominant		H6
7b.	*Stipa richardsonii* dominant, *Koeleria cristata* codominant		H13
	8a.	Site subhydric to hydric, very poorly drained	9
	8b.	Site drier and better drained	10
9a.	*Eriophorum angustifolium* dominant		H10
9b.	*Carex aquatilis* or *Carex rostrata* dominant		H11
9c.	*Caltha leptosepala* and *Trollius albiflorus* codominant		H9
	10a.	Lichens dominant, sparsely vegetated, high Alpine elevations	H12
	10b.	Graminoids dominant	11
	10c.	Forbs dominant	14
11a.	*Carex* spp. dominant		12
11b.	*Elymus innovatus* dominant		13
	12a.	*Carex nigricans* dominant, Alpine snowbed	H2
	12b.	*Carex scirpoidea* dominant, Montane–Lower Subalpine fluvial site	H3
13a.	*Fragaria virginiana, Epilobium angustifolium* abundant, site mesic		H5
13b.	*Koeleria cristata, Arctostaphylos uva-ursi* (*Hedysarum sulphurescens* in Banff) abundant, site subxeric		H14
13c.	*Saxifraga bronchialis* abundant, site xeric to subxeric		H20
	14a.	Site subxeric to xeric, *Saxifraga bronchialis* and *Elymus innovatus* dominant	H20
	14b.	Site mesic to hygric, *Saxifraga bronchialis* and *Elymus innovatus* usually absent	15
15a.	*Caltha leptosepala* and *Trollius albiflorus* dominant		H9
15b.	*Erigeron peregrinus* and *Valeriana sitchensis* dominant		H16

SIGNIFICANT SPECIES

During the Ecological Land Classification, four species of vascular plants and two species of lichens new to Alberta were collected. *Hippuris montana* Ledeb. was collected in wet Alpine areas of western Jasper and occurs otherwise in Alaska, Yukon, Northwest Territories, British Columbia and Washington. *Sedum divergens* Watson was collected on rocky, Subalpine avalanche slopes in northern Jasper and occurs also in Washington, Oregon, British Columbia, and southeastern Alaska. *Tsuga heterophylla* (Raf.) Sarg. (western hemlock) was collected in moist *Picea engelmannii–Abies lasiocarpa* Subalpine forests along the Continental Divide in northern Banff and western Jasper. It ranges from southern Alaska to California, and interior British Columbia to northwestern Montana and western Alberta. *Vaccinium ovalifolium* J. E. Smith (oval-leaved blueberry) was collected in moist Lower Subalpine *Picea engelmannii–Abies lasiocarpa* forests in northern Banff and in northern and western Jasper. This wide ranging species also occurs in Alaska, Washington, Oregon, Idaho and western Montana as well as eastern North America and eastern Asia. The lichen *Caloplaca epithallina* Lynge was collected in dry Upper Subalpine grassland in both Banff and Jasper and occurs otherwise in New Mexico, Colorado, South Dakota, and Greenland. The other lichen, *Thelidium decipiens* (Nyl.) Kremp. was collected in the Alpine of Banff and is circumpolar, arctic–alpine in range. These six species all have small populations in the parks and are rare as defined below.

A list of rare species both vascular and nonvascular, was compiled. A rare vascular species is considered to occur within a restricted geographical area, usually <500 km², and at usually <10 collection sites. Also, the plant is often at the edge of its

geographical range. All three criteria generally indicate a small population in the parks. In addition, a list of nearly rare plants and those with a range boundary in the parks was also compiled. The list of 152 rare vascular species and 28 nearly rare or range boundary species is in Volume II of this report along with information on occurrence in the parks. A list of 57 rare liverworts and mosses, and 30 rare lichens is also contained in Volume II. Further information on these species is in Volume II of this report. Due to a more limited knowledge of the ranges and abundances of nonvascular as compared to vascular plants, a slightly different definition of "rare" was used. The status "rare" was based on an abundance scale (dominant, common, infrequent, uncommon, rare) reflecting the quantity of the species in the parks as assessed by botanists familiar with the bryophytes and lichens of the Rocky Mountains.

WILDLIFE

The most spectacular, observable wildlife of Banff and Jasper National Parks are the eight species of ungulates. They occur in the parks primarily because of the availability of suitable habitat and the protection provided by the National Parks Act. Steep terrain and flat valley bottoms provide a variety of grasslands, shrub meadows and forests which, combined with moderate snow fall and areas of low snow accumulation, allow these species to forage in the winter. Much of the vegetated portion of the parks is used only in summer by elk, mule deer and white-tailed deer because winter snow accumulations are too deep for efficient travel and foraging. Part of the populations of these species is able to survive the winter within the parks, while the remainder winter outside the parks. Most sheep, goats, moose and caribou are resident in the parks year-round. Bison occurred in the mountains historically and recently one bull has survived in the lower Athabasca Valley in Jasper since 1978.

The number and variety of ungulates and other prey sustain a wide variety of carnivores. Wolves and coyotes are relatively common in Jasper. In Banff, wolves are relatively rare and most packs range east of the park, while coyotes are relatively common. Red foxes occur in both parks but are rare. Cougars are very rare, with most sightings near the townsites. Lynx are widespread but uncommon. There is a great variety of *Mustelidae*, the weasel family, in both parks. Martens and ermines are common in all forested areas. Fishers are rare and only occur in forests along the Continental Divide. Long-tailed weasels, least weasels and mink are uncommon throughout both parks. The present status of otters is not fully known but they are generally rare. Badgers have a spotty distribution in Banff.

Black bears and grizzly bears occur throughout both parks. Grizzlies are more common in the Front Ranges than the Main Ranges. Black bears have not been studied but appear to be more abundant in the Main Ranges and at lower elevations.

In addition, there are 34 other species of mammals that occur or have occurred in the two parks. There are four species of shrews; the water and pigmy shrews are rare. Seven species of bats have been recorded in in the parks. All are rare or uncommon but the big-brown and little-brown bats are the most common. Three species of lagomorphs have been recorded. Pikas and varying hares are relatively common and there is one specimen record of white-tailed jack rabbit. The remaining twenty species of mammals belong to the order *Rodentia*. The most common are deer mouse, Gapper's red-backed vole, red squirrel and Columbian ground squirrel. The Northern pocket gopher is suspected to occur only at the Ghost Lakes in Banff while the Richardson's water vole is rare but patchily distributed in both parks. Northern flying squirrels are present and widespread but their abundance is not known. Muskrats are restricted to low elevation ponds but beavers periodically invade valleys up to treeline.

Banff and Jasper National Parks support a wide variety of birds particularly during spring and summer. The great elevational range (1050 to 3350 m) and the varied terrain results in a diversity of habitats that contribute to the variety of birdlife. Also,

species characteristic of both eastern and western Canada come into contact along the Rocky Mountains. So far, 281 species have been recorded in both parks.

Alpine species, such as white-tailed and willow ptarmigan, grey-crowned rosy finch, golden-crowned sparrow, water pipit and horned lark occur in most high elevation meadows. A few species of waterfowl breed at lower elevations. Many others migrate through the mountains in small to moderate numbers. Most notable among the raptors are the breeding population of golden eagles and the small autumn migration of prairie and peregrine falcons. Migrating shorebirds occur in small numbers on lakes at all elevations. Twelve species of owls have been recorded in the two parks but only eight appear to have bred here. Black swifts nest at Maligne and Johnston Canyons, the only known breeding sites in Alberta. Most species of warblers and vireos occur at low elevations while sparrows are distributed into the Alpine. Dippers inhabit most streams and in winter some are concentrated on the Bow River below Banff townsite. The seven species of corvids are among the most obvious of the parks' avifauna.

Amphibians and reptiles are less common than birds. Of the six species only the western toad is widespread. Wood frogs and spotted frogs breed in Montane and Subalpine ponds while the long-toed salamander is restricted to some Montane ponds. The boreal chorus frog occurs in the lowest portion of the Montane in the Athabasca Valley. Wandering garter snakes are rare even at the lowest elevations. The warm springs at the Cave and Basin in Banff provide the only known snake hibernaculum.

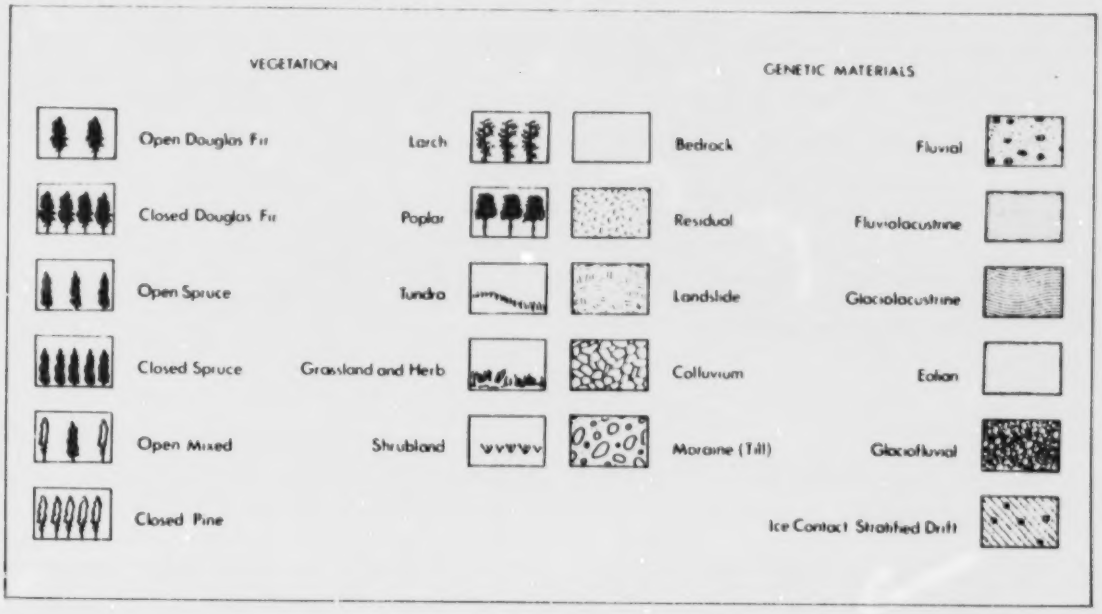
Further details on all species of wildlife are in the species accounts in Volume III and the bird checklist.

CHAPTER III - SUMMARY ECOSECTION/ECOSITE DESCRIPTIONS

ECOSYSTEM/ECOSITE DESCRIPTIONS.....B.D. Walker, W.S. Taylor, D.T. Allan, I.G.W. Corns and W.D. Holland
WILDLIFE.....G.L. Holroyd and K.J. Van Tighem

The Ecosite descriptions in this section are abbreviated from the information given for soils and vegetation in Volume II, and wildlife in Volume III. They summarize the main features of these resources and are arranged alphabetically by the two letter abbreviation. Fig. 7 is a legend of the symbols used in the landscape schematics.

Fig 7. Legend of symbols used in Ecosite landscape schematics.



The interpretive comments in the Management Considerations section use a common or dominant element selected from the entire ecological concept of an Ecosection. For example, the effect of coarse texture is highlighted for glaciofluvial deposits such as AT or BV and the effect of poor drainage is emphasized in Ecosections like CV. Yet, the comments do not represent just one of the resource disciplines. Thus, the interpretive guidelines used in Waterton Lakes National Park or Yoho National Park may result in limitations for soils that are different than the evaluation used in Banff-Jasper where a more holistic ecological concept was adopted.

AL - ALTRUDE ECOSECTION

The Altrude (AL) Ecosection encompasses calcareous fluvial fan and apron landforms dominated by Brunisolic soils and lodgepole pine or Engelmann spruce-subalpine fir forests within the Lower Subalpine portion of the Subalpine Ecoregion. AL occurs primarily on lower slopes and floors of valleys. Two AL Ecosites are separated by vegetational differences as outlined in Table 17.

Table 17. General features of the AL Ecosites.

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
AL1	Fan & apron	Fluvial material B (calcareous, coarse-stratified)	Eutric Brunisol	Lodgepole pine forest (C19)
AL2	Fan & apron	Fluvial material B (calcareous, coarse-stratified)	Eutric Brunisol	Engelmann spruce - subalpine fir forest (C13,C31).

AL surfaces are often channeled. Slopes range from 2 to 45%. Orthic and Cumulic Regosols occur in narrow strips along present and recently abandoned stream channels. Soils are well to moderately well drained.

WILDLIFE

Table 18. Wildlife features of the AL Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
AL1	high	deer elk	high	wolverine lynx wolf cougar coyote	medium	snowshoe hare columbian ground squirrel golden-mantled ground squirrel western jumping mouse	medium
AL2	low	moose	high	coyote	medium	red squirrel red-backed vole porcupine	high

AL is moderately to highly important to wildlife. AL1 includes highly important habitat for some ungulates and carnivores while AL2 is highly important for coyotes. A large number of small mammal species occur in the AL Ecosection but only in moderate numbers. While both Ecosites receive moderate snowfall, AL1 is warmer because of more southerly exposure.

MANAGEMENT CONSIDERATIONS

AL tracts with gentle slopes generally have no landform, soil, or vegetational characteristics limiting campground, trail, or related uses. Locally occurring coarse textures and high water tables may present problems for sewage disposal; on the other hand, the coarse textured material provides gravel for construction.

Most of the AL tracts have streams that provide suitable domestic water supplies.

EACH TRACT SHOULD BE EVALUATED IN DETAIL FOR SPECIFIC PROPOSED USES.

AT - ATHABASCA ECOSECTION

The Athabasca (AT) Ecosection encompasses terraced landforms of calcareous glaciofluvial material in the Montane Ecoregion. It is dominated by Brunisolic soils and either lodgepole pine forest or a pattern of dry grassland > lodgepole pine forest. Two Ecosites are separated on the basis of vegetational differences as outlined in Table 19. Representative landscape positions are shown in Figs. 24 and 27.

Table 19. General features of the AT Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
AT1	Terraced	Glaciofluvial material B (calcareous, coarse textured)	Eutric Brunisol	Lodgepole pine forest (C3, C6, C19)
AT3	Terraced	Glaciofluvial material B (calcareous, coarse textured)	Eutric Brunisol	Dry grassland (H6) > lodgepole pine forest (C3)

AT1 and AT3 occur on broad valley floors. The terraced surfaces are often channeled. Slopes range from 1 to 15%. A thin veneer of Eolian material B (altered, medium textured) occurs commonly in southern Banff and sporadically in southwestern Jasper; a thin veneer of Eolian material A (calcareous, medium textured) occurs from Jasper townsite eastward in the Athabasca River valley and near Saskatchewan Crossing in Banff. Soils are rapidly to well drained; many AT3 soils have a thin, surficial deposit of calcareous eolian material.

WILDLIFE

AT is very important to wildlife especially ungulates, carnivores and bats. Some small mammals also occur in large numbers. The relatively warm temperature and low snow

Table 20. Wildlife features of the AT Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
AT1	very high	elk deer	very high	cougar wolf coyote lynx	medium	bat snowshoe hare red squirrel deer mice	medium
AT3	very high	deer elk	high	weasel coyote wolf cougar	high	deer mouse	high

accumulation contribute to the suitability for wildlife. Critical ungulate habitat occurs on these Ecosites particularly when there are interspersed grasslands.

MANAGEMENT CONSIDERATIONS

Level topography and valley floor positions within the warm, dry Montane Ecoregion are conducive to many uses. The coarse textures provide extensive and readily available gravel and sand supplies. Because of ineffective ion filtration, AT should be tested before use for sewage disposal. Such coarse textures allow easy passage of water and thus, the soils are droughty, causing slow vegetation growth and problems in revegetation. In addition, AT is of limited areal extent and its unforested segments attract many uses.

AZ - AZURE ECOSECTION

The Azure (AZ) Ecosection has a dry > wet landscape pattern on hummocky and ridged landforms consisting of noncalcareous, coarse textured, ice contact stratified drift in the Upper Subalpine portion of the Subalpine Ecoregion. Dystric Brunisols and Engelmann spruce - subalpine fir open forest characterize dry (rapidly to well drained) upland segments. Wet (imperfectly to poorly drained) depressional segments are dominated by Gleysolic and Organic soils under wet shrub thicket and wet herb meadow vegetation. General features of the AZ1 Ecosite are outlined in Table 21. Its landscape position is shown in Fig. 8.

AZ1 occurs on lower slopes and floors of a few broad valleys. Slopes range from 5 to 45%. The strongly eluviated soils have thick Ae horizons, thick sola, and weakly cemented B horizons (duric tendency).

WILDLIFE

This Upper Subalpine Ecosite is moderately important to wildlife in summer. Deep snow restricts animal activity in winter.

Fig. 8. Landscape schematic of the Azure (AZ1) and Topaz (TZ1) Ecosites in relation to other Ecosites.

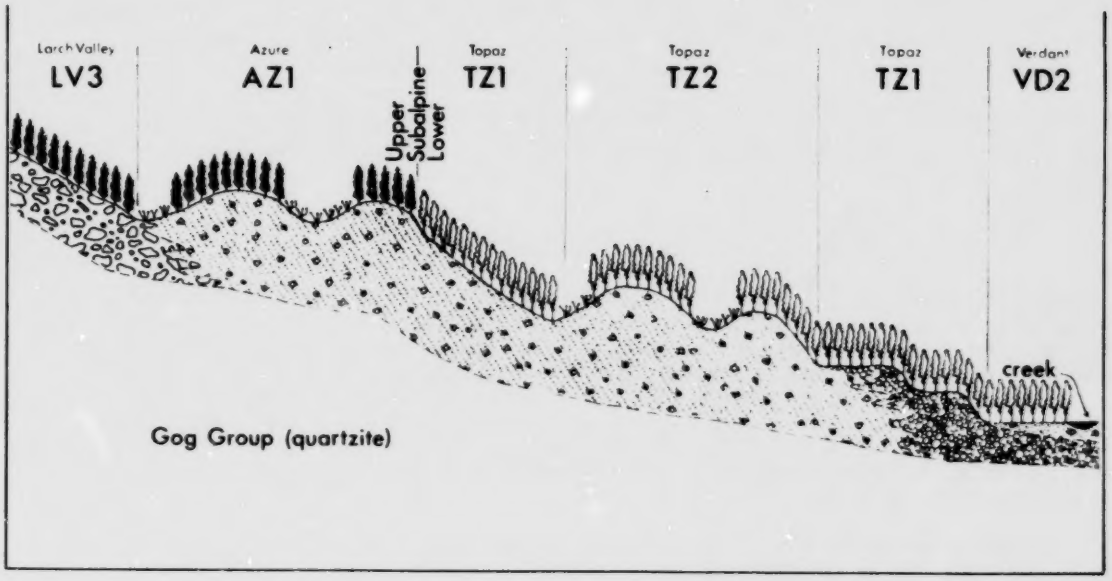


Table 21. General features of the AZ1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
AZ1	Hummocky & ridged	Ice contact stratified Drift A (noncalcareous, coarse textured)	Dry 70: Dystric Brunisol Wet 30: Gleysol > Mesisol	Engelmann spruce-subalpine fir open forest (O10) Wet shrub thicket (S8), wet herb meadow (H9)

MANAGEMENT CONSIDERATIONS

AZ1 is of limited areal extent. The coarse textured material provides gravel and sand for construction, but may present problems if used for sewage disposal because such coarse textured materials are ineffective ion filters. The dry > wet landscape pattern necessitates special considerations in trail locations and campsite construction. The

Table 22. Wildlife features of the AZ1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
AZ1	medium	caribou deer	low	cougar	low	heather vole yellow pine chipmunk	high

coarse textures are also expected to contribute to slow vegetation growth and regeneration.

BK - BAKER CREEK ECOSECTION

The Baker Creek (BK) Ecosection encompasses a dry > wet landscape pattern on ridged and hummocky landforms of calcareous glacial material in the Lower Subalpine portion of the Subalpine Ecoregion. Dry (well drained,) upland segments are dominated by an Eutric Brunisol > Gray Luvisol soil complex and lodgepole pine or Engelmann spruce – subalpine fir forests. Wet (poorly to very poorly drained) depressional segments are dominated by Gleysolic and Organic soils under wet spruce open forest, wet shrubby meadow, and birch fen. Three BK Ecosites are differentiated by genetic material and vegetational differences as outlined in Table 23. Relative landscape positions are shown in Fig. 9.

Slopes commonly range from 5 to 45%. Surficial veneers of Eolian material B (altered, medium textured) occur extensively in western Banff and southwestern Jasper, sporadically elsewhere. BK Ecosites usually occur on the benchland of broad river valley floors.

WILDLIFE

BK is highly important to wildlife. Although deep snow limits use by large mammals in winter, many species occur here in large numbers in the summer. All BK Ecosites are important to moose year–round. The mosaic of wet and dry habitats contributes to the importance of this Ecosection to wildlife.

MANAGEMENT CONSIDERATIONS

Dry portions of BK1 generally have no landform, soil or vegetational limitations for campgrounds, trails or related uses. However, the characteristic dry > wet landscape pattern necessitates special considerations in trail location and construction. BK4 and BK6 have locally occurring coarse textured materials that provide gravel sources but, conversely, may present problems in sewage disposal because of ineffectiveness in ion filtration.

BP - BOULDER PASS ECOSECTION

The Boulder Pass (BP) Ecosection encompasses hummocky landslide landforms in the Upper Subalpine portion of the Subalpine Ecoregion. Brunisolic and Regosolic soils dominate along with mixed coniferous open forest, Engelmann spruce–subalpine fir open and closed forest, and subalpine larch – subalpine fir forest. Two BP Ecosites are differentiated by soil and vegetation characteristics as outlined in Table 25.

Table 23. General features of the BK Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
BK1	Hummocky & ridged including bedrock control(blanket)	Till C (calcareous, medium textured)	Dry 70: Eutric Brunisol > Gray Luvisol	Lodgepole pine forest (C18,C19)
			Wet 30: Gleysol, Mesisol	Wet spruce open forest (O11), wet shrubby meadow(S1), birch fen (S3)
BK4	Hummocky & ridged including bedrock control (blanket)	Ice contact stratified Drift B (calcareous, variably textured)	Dry 70: Eutric Brunisol > Gray Luvisol	Lodgepole pine forest (C18, C19)
			Wet 30: Gleysol, Mesisol	Wet spruce open forest (O11), wet shrubby meadow (S1), birch fen (S3)
BK6	Hummocky & ridged including bedrock control (blanket)	Till C (calcareous, medium texture) & Ice contact stratified Drift B (calcareous, variably textured)	Dry 70: Eutric Brunisol	Engelmann spruce - subalpine fir forest (C13)
			Wet 30: Gleysol, Mesisol	Wet spruce open forest (O11), wet shrubby meadow (S1), birch fen (S3)

Relative landscape positions are shown in Fig. 10.

Surfaces are often stony and bouldery. Slopes are usually complex and range from 15 to 70%. Veneers of Eolian material B (altered, medium textured) are common on BP2 tracts in western Banff and southwestern Jasper. Soils are rapidly to moderately well drained. Eutric Brunisols occur on calcareous materials, Dystric Brunisols on noncalcareous materials. Occurrences of subalpine larch - subalpine fir forest (C23) are restricted to southern Banff. Unvegetated portions may constitute up to 50% of BP1 tracts.

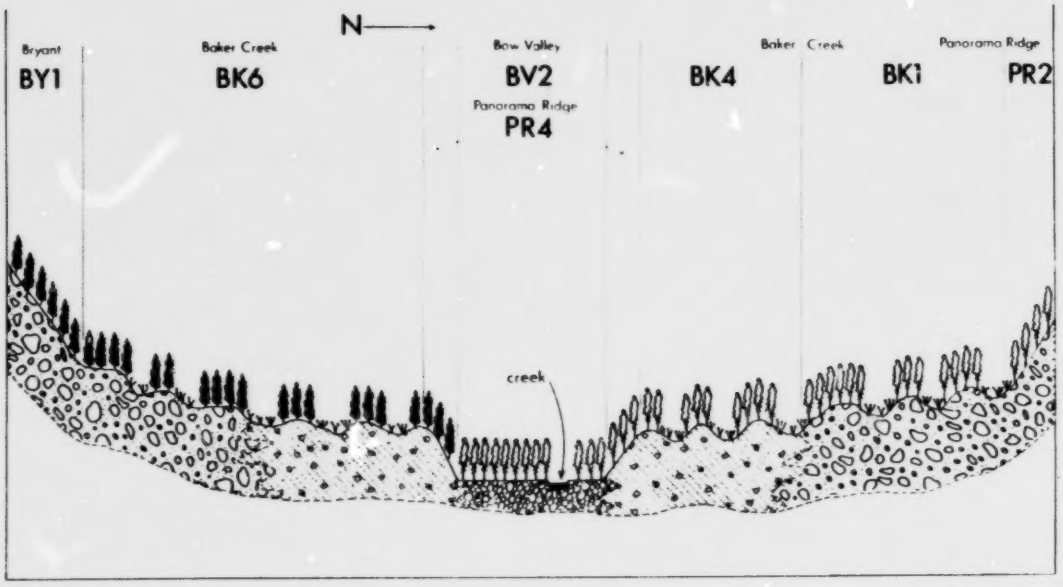
WILDLIFE

This Ecosection is of low importance to wildlife with the exception of goats. Goats forage here and probably rest in BP tracts during winter storms where BP areas occur adjacent to better foraging land. In addition, a few small mammal species occur here in high densities.

MANAGEMENT CONSIDERATIONS

BP1 has irregular topography, moderate to steep slopes, and rubbly, blocky surfaces that are limiting for campgrounds and related uses and should be considered when planning trails and roads. Vegetation is expected to recover slowly from disturbances, including fire. BP2 has limiting factors similar to those of BP1 but not as severe because fine earth materials thinly mantle the rubbly, blocky landslide deposits. As a result, the closed to open forest is thought to be more resilient to surface distrubances.

Fig. 9. Landscape schematic of the Baker Creek (BK) Ecosites in relation to other Ecosites.



BS - BOW SUMMIT ECOSECTION

The Bow Summit (BS) Ecosection encompasses inclined landforms consisting of calcareous, medium textured colluvium in the Alpine Ecoregion. It is dominated by Brunisolic and Regosolic soils and mountain avens tundra vegetation. The features of BS1 are outlined in Table 27. The landscape position of BS1 is shown in Figs. 28 and 30.

BS1 occurs on steep, usually linear slopes in areas dominated by calcareous bedrock. Slopes range from 45 to 100%. Colluvial processes are locally active and include avalanching, soil creep, cryoturbation, and solifluction. Soils are well drained. Unvegetated portions may occupy up to 50% of BS1 tracts.

WILDLIFE

This Ecosite is of low importance to most species but highly important to ungulates and some small mammals. The major attraction for ungulates is the lack of deep winter snow in these windswept areas. Rocky areas are highly important to pika and golden-mantled ground squirrels while finer soils are highly important to marmot and columbian-ground squirrel.

Table 24. Wildlife features of the BK Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
BK1	medium	moose deer elk	high	marten wolverine coyote wolf cougar	high	masked shrew red squirrels red-backed vole meadow vole western jumping mouse	high
BK4	high	elk deer moose	very high	wolf cougar coyote marten lynx	medium	snowshoe hare red-backed vole	medium
BK6	low	moose	very high	coyote marten lynx cougar	medium	snowshoe hare red-backed vole	medium

MANAGEMENT CONSIDERATIONS

Steep and locally unstable (colluviating) slopes are limiting factors for many park uses Removal of vegetation is likely to result in wind, water, and gravitational erosion. Vegetation is expected to recover slowly from disturbances.

BV - BOW VALLEY ECOSECTION

The Bow Valley (BV) Ecosection consists of terraced landforms of calcareous glaciofluvial material and occurs in the Lower Subalpine portion of the Subalpine Ecoregion It is dominated by Brunisolic soils and either lodgepole pine or Engelmann spruce-subalpine fir forest. Three BV Ecosites are separated by vegetational differences as outlined in Table 29. Landscape positions are shown in Fig. 11.

The BV Ecosites generally occur on broad valley floors. The terraced surfaces are often channeled. Slopes range from 1 to 15%. A thin veneer of Eolian material B (altered, medium textured) is common in western Banff and southwestern Jasper. Soils are rapidly to well drained.

WILDLIFE

This Ecosection is moderately important to wildlife. Although some species occur in high numbers, this Ecosection has less wildlife than most other Montane Ecosections.

MANAGEMENT CONSIDERATIONS

Level topography and valley floor positions are conducive to many uses. The coarse textures provide extensive and readily available gravel supplies but such coarse textured material is ineffective as an ion filter, a factor to be considered when designing sewage disposal systems. Water easily passes through these materials and and

Fig. 10 Landscape schematic of the Boulder Pass (BP) Ecosites in relation to other Ecosites.

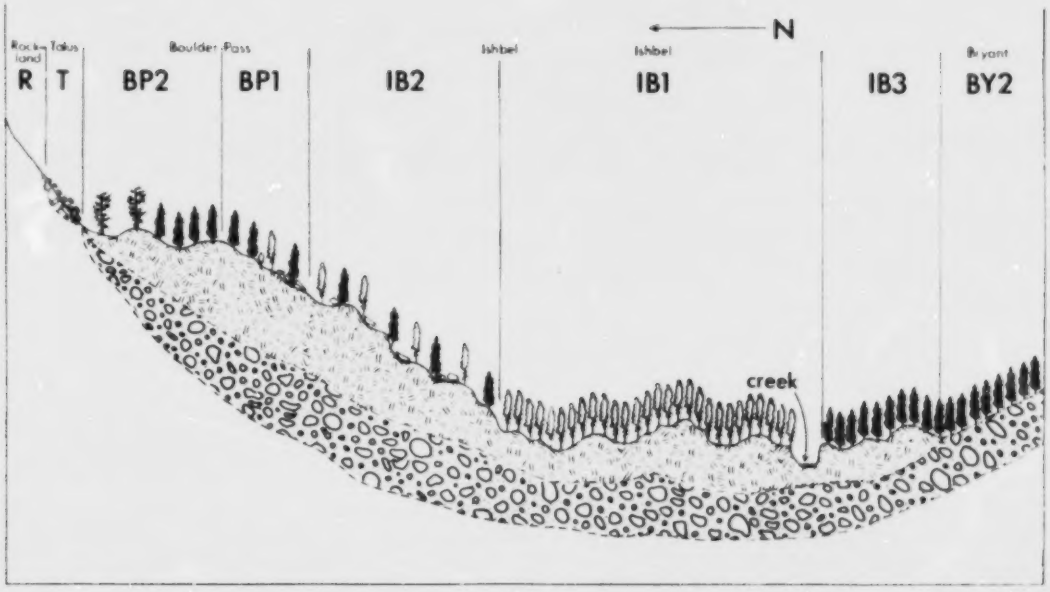


Table 25. General features of the BP Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
BP 1	Hummocky	Landslide material (variable calcareousness and texture)	Eutric & Dystric Brunisol, Regosol	Mixed coniferous open forest (O4)
BP 2	Hummocky	Landslide material (variable calcareousness and texture)	Eutric Brunisol	Engelmann spruce-subalpine fir closed & open forest (C15, O10), subalpine larch-subalpine fir forest (C23).

problems in revegetation may occur. Vegetational growth rates are slow.

Table 26. Wildlife features of the BP Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
BP1	medium	mountain goat	low	marten weasel	medium	dusky shrew pika columbian ground squirrel northern bog lemming long-tailed vole	low
BP2	medium	mountain goat	low		low	least chipmunk heather vole	low

Table 27. General features of the BS1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
BS1	Blanket & veneer over inclined bedrock	Colluvium C. (calcareous, medium textured)	Eutric & Melanic Brunisol, Regosol, Humic Regosol	Mountain avens tundra (Dl).

Table 28. Wildlife features of the BS1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
BS1	high	bighorn sheep mountain goat	low		low	pika hoary marmot columbian ground squirrel golden-mantled ground squirrel	low

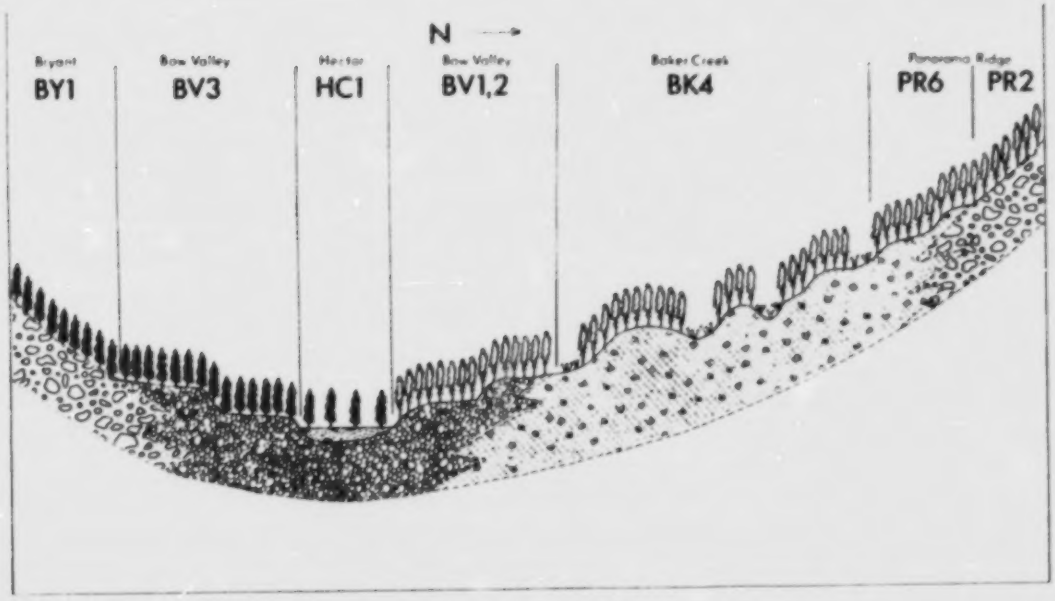
BY - BRYANT ECOSECTION

The Bryant (BY) Ecosection encompasses calcareous glacial landforms dominated by Engelmann spruce-subalpine fir forest in the Lower Subalpine portion of the Subalpine

Table 29. General features of the BV Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
BV1	Terraced	Glaciofluvial material B (calcareous, coarse textured)	Eutric Brunisol	Lodgepole pine forest (C9, C18, C19)
BV2	Terraced	Glaciofluvial material B (calcareous, coarse textured)	Eutric Brunisol	Lodgepole pine forest (C20, C24)
BV3	Terraced	Glaciofluvial material B (calcareous, coarse textured)	Eutric Brunisol	Engelmann spruce - subalpine fir forest (C13, C31)

Fig 11 Landscape schematic of the Bow Valley (BV) Ecosites in relation to other Ecosites



Ecoregion. Eutric Brunisols are the dominant soils. Three BY Ecosites are

Table 30. Wildlife features of the BV Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
BV1	medium	moose	high	coyote lynx	medium	snowshoe hare red squirrel meadow vole porcupine	high
BV2	low		medium	marten	medium	red-backed vole	high
BV3	low	deer moose	low	wolf cougar	high	masked shrew red-backed vole western jumping mouse	low

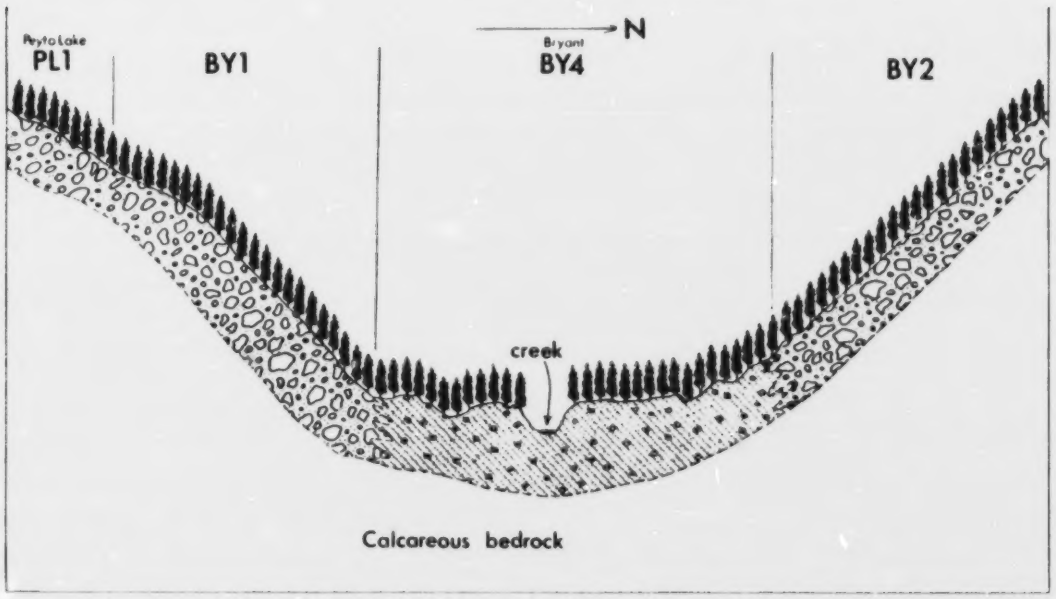
differentiated by genetic material, soil, and vegetational distinctions as outlined in Table 31. Landscape positions are shown in Fig. 12.

Table 31. General features of the BY Ecosites.

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
BY1	Blanket over inclined bedrock	Till C (calcareous, medium textured)	Eutric Brunisol > Humo-Ferric Podzol	Engelmann spruce - subalpine fir forest (C14, C21)
BY2	Blanket over inclined bedrock	Till C (calcareous, medium textured)	Eutric Brunisol	Engelmann spruce - subalpine fir forest (C13, C30, C31)
BY4	Blanket over inclined and hummocky bedrock, hummocky	Ice contact stratified Drift B (calcareous, variably textured)	Eutric Brunisol	Engelmann spruce - subalpine fir forest (C13, C14, C30)

BY1 occurs most often on northerly aspects in western Banff and Jasper; BY2 occurs most often in eastern Banff and Jasper. Slopes range from 15 to 70% and are often gullied on BY1 and BY2, 5 to 45% for BY4. Surficial veneers of Eolian material B (altered, medium textured) occur extensively in western Banff and Jasper and are therefore most abundant on BY1. The development of Bf, podzolic Bf, and similar horizons is related to the occurrence of Eolian material B. Soils are well to moderately well drained.

Fig. 12 Landscape schematic of the Bryant (BY) Ecosite in relation to other Ecosites.



WILDLIFE

This Ecosection is moderately important to wildlife. BY2 is highly important to caribou in Jasper. Snowshoe hare and lynx are common on BY2 and BY4. Breeding birds typical of subalpine spruce-fir forest occur in high densities in this Ecosection.

MANAGEMENT CONSIDERATIONS

Steepness of slope is a factor to consider in planning park uses. Eolian material B veneers are extensive on many BY1 tracts and tend to erode easily where vegetation is removed. Locally occurring avalanche paths and seeps may affect certain park uses on BY1 and BY2. BY4 has no characteristics limiting for campgrounds, trails or related uses. Locally occurring gravel sources on BY4 may present problems if such sites are used for sewage disposal (ineffective ion filtration).

BZ - BRAZEAU ECOSECTION

The Brazeau (BZ) Ecosection encompasses hummocky residual landforms within the Lower Subalpine portion of the Subalpine Ecoregion. It is dominated by lithic Brunisolic

Table 32. Wildlife features of the BY Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
BY1	low	moose	medium		high	red-backed vole porcupine	high
BY2	medium	caribou moose	high	lynx coyote	medium	snowshoe hare red-backed vole porcupine	low
BY4	low		high	marten lynx	low	snowshoe hare	high

soils and Engelmann spruce–subalpine fir or lodgepole pine forests. Two BZ Ecosites are separated by vegetational differences as outlined in Table 33.

Table 33. General features of the BZ Ecosites.

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
BZ 1	Hummocky	Residuum A (noncalcareous medium textured) and Residuum B (calcareous, medium textured)	Eutric and Dystric Brunisol (lithic phases)	Engelmann spruce - subalpine fir forest (C30, C31)
BZ 2	Hummocky	Residuum A (noncalcareous, medium textured) and Residuum B (calcareous, medium textured)	Eutric and Dystric Brunisol (lithic phases)	Lodgepole pine forest (C18, C29)

The landforms usually consist of failed Mesozoic shale bedrock that now occupies valley floor and lower slope positions. Slopes range from 5 to 15% on BZ1 and 15 to 45% on BZ2. Soils are well drained. Dystric Brunisols are associated with Residuum A; Eutric Brunisols with Residuum B. BZ occurs only in Jasper.

WILDLIFE

BZ is moderately important to wildlife but highly important to small mammals, moose and deer. Red-backed vole occurs in high densities here.

Table 34. Wildlife features of the BZ Ecosites

Ecosite	Ungulates		Carnivores		Small Mammals		Birds
	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
BZ1	medium	moose deer	medium	weasel	high	deer mouse red-backed vole	low
BZ2	medium	moose deer	low	marten	high	red-backed vole	medium

MANAGEMENT CONSIDERATIONS

BZ1 and BZ2 are of very limited areal extent. Shallow soils and bedrock are the major factors to consider in planning of park uses.

CA - CAVELL ECOSECTION

The Cavell (CA) Ecosection encompasses morainal landforms consisting of noncalcareous, medium textured till within the Lower Subalpine portion of the Subalpine Ecoregion. It is dominated by Dystric Brunisols and Engelmann spruce-subalpine fir or lodgepole pine forests. Three CA Ecosites are separated by a dry > wet landscape pattern and vegetational differences as outlined in Table 35. Landscape positions are shown in Fig. 13.

The dry > wet CA1 frequently includes failed slopes and occurs on valley floors including benchlands and on lower valley wall slopes. A few CA1 tracts are dominated by Till A (noncalcareous, coarse textured), a few others by a medium textured variant of Ice Contact Stratified Drift A (noncalcareous, coarse textured). Slopes range from 5 to 45%. Dry segments have well to moderately well drained soils; wet segments have poorly to very poorly drained soils.

Slopes for CA2 and CA4 range from 15 to 70%; soils of these two Ecosites are well to moderately well drained.

Surficial veneers of Eolian material B (altered, medium textured) occur extensively on CA1 and CA2 in western Banff and southwestern Jasper, sporadically on CA4. Occasional occurrences of Humo-Ferric Podzols are associated with the eolian veneers.

WILDLIFE

This Ecosection is moderately important to wildlife. It is highly important to some carnivores and small mammals. Deep winter snow restricts large mammal activity.

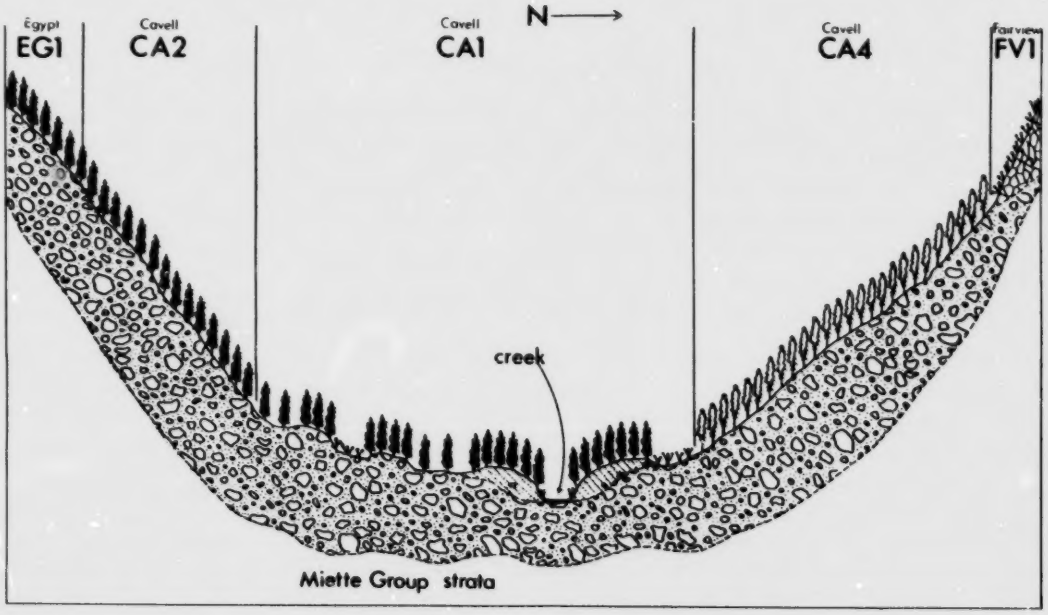
MANAGEMENT CONSIDERATIONS

Dry portions of CA1 have no characteristics limiting for campgrounds, trails, or related park uses. The characteristic dry > wet landscape requires special considerations in trail location and construction. Removal of surface and subsurface materials may

Table 35. General features of the CA Ecosites.

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
CA1	Hummocky & ridged including bedrock control (blanket)	Till B (noncalcareous, medium textured)	Dry 70: Dystric Brunisol Wet 30: Gleysol, gleyed Podzolic, Mesisol	Engelmann spruce - subalpine fir forest (C14, C13, C21) Wet spruce open forest (O11), wet Engelmann spruce-subalpine fir open forest (O14), wet shrubby meadow (S1), birch fen (S3).
CA2	Blanket over inclined bedrock	Till B (noncalcareous, medium textured)	Dystric Brunisol	Engelmann spruce - subalpine fir forest (C14, C13, C21).
CA4	Blanket over inclined bedrock	Till B (noncalcareous, medium textured)	Dystric Brunisol	Lodgepole pine forest (C19, C20).

Fig. 13 Landscape schematic of the Cavell (CA) Ecosites in relation to other Ecosites.



create seepage-induced slope failure. Steepness of slope is the major factor to consider in planning park uses for CA2 and CA4. Also, avalanche paths and seeps will affect certain uses locally.

Table 36. Wildlife features of the CA Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
CA1	medium		high	marten weasel lynx	medium	masked shrew snowshoe hare red-backed vole	high
CA2	low		high	marten lynx	medium	snowshoe hare red-backed vole	medium
CA4	medium	moose	medium	marten	medium	deer mice red-backed vole	low

CN - CYCLONE ECOSECTION

The Cyclone (CN) Ecosection encompasses fluvial fan and apron landforms dominated by Regosolic soils and dry to moist shrub thicket vegetation in the Upper Subalpine portion of the Subalpine Ecoregion. It occurs on valley floors and lower slopes mainly within the Front Ranges. The features of the CN1 Ecosite are outlined in Table 37. Landscape position is shown in Fig. 30.

Table 37. General features of the CN1 Ecosite.

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
CN1	Fan, apron	Fluvial materials A & B (noncalcareous & calcareous, coarse-stratified)	Regosol, Humic Regosol	Dry shrub thicket (S10), moist shrub thicket (S12)

Fluvial blankets, terraces, and level floodplains occur in minor amounts. Modification by snow avalanching and channeling is common. Slopes range from 5 to 45%. Soils are well to moderately well drained although some tracts contain small wet sites.

WILDLIFE

Table 38. Wildlife features of the CN1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
CN1	high	elk	low	coyote cougar	high	columbian ground squirrel deer mouse heather vole meadow vole long-tailed vole	low

This shrubby Ecosection is highly important to all wildlife, particularly small mammals and, in summer and autumn, elk.

MANAGEMENT CONSIDERATIONS

Regosolic soils dominate, therefore flooding is sufficiently frequent to maintain these weakly developed soils. Frequency and magnitude of depositional processes are major factors to consider in planning park uses. Locally occurring coarse textures and high water tables present problems for sewage disposal. Coarse textured materials provide gravel supplies. Many tracts are avalanched.

EACH TRACT SHOULD BE EVALUATED IN DETAIL FOR SPECIFIC PROPOSED USES.

CP - COPPER ECOSECTION

The Copper (CP) Ecosection encompasses residual landforms in the Upper Subalpine portion of the Subalpine Ecoregion. It is dominated by lithic Dystric Brunisols and Engelmann spruce–subalpine fir open and closed forests and subalpine larch–subalpine fir forest. The features of the CP1 Ecosite are outlined in Table 39. Landscape position is shown in Fig. 14.

CP1 occurs primarily on valley shoulders and spurs; some tracts occur on failed bedrock. The parent material is weathered from either Miette Group bedrock in the Main Ranges or noncalcareous Mesozic strata in the Front Ranges. Surficial veneers of Eolian material B (altered, medium textured) occur extensively in western Banff, sporadically elsewhere. Limited occurrences of Humo–Ferric Podzols are associated with the eolian veneers. Slopes range from 15 to 60%. Soils are well to moderately well drained. Occurrences of subalpine larch–subalpine fir forest (C23) are restricted to southern Banff.

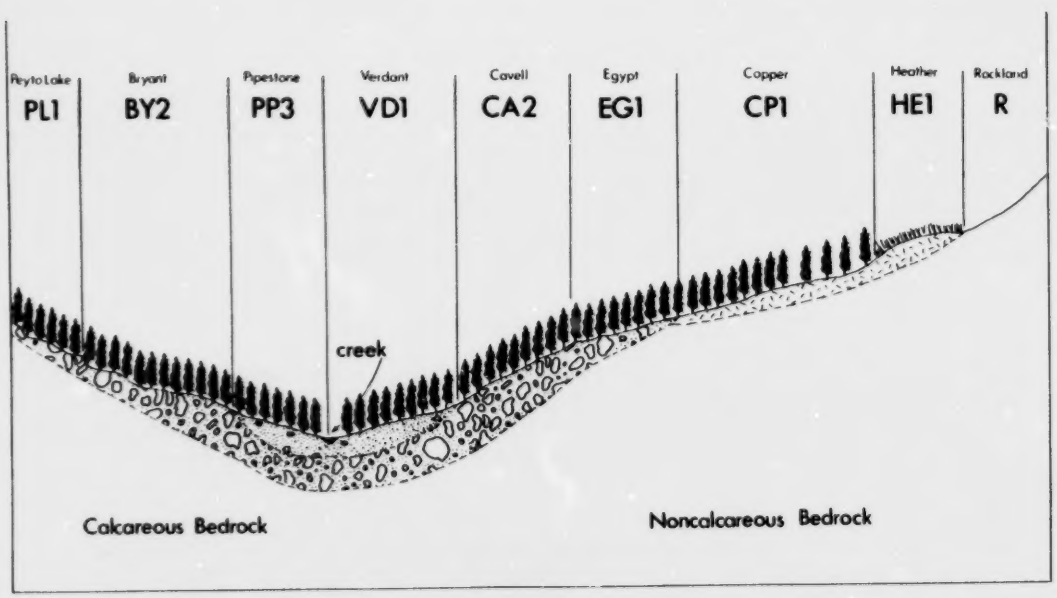
WILDLIFE

This rocky Ecosection is moderately important to wildlife, although few species occur here in large numbers.

Table 39. General features of the CP1 Ecosite.

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
CP1	Inclined, hummocky, & ridged	Residuum A (noncalcareous, medium textured)	Dystric Brunisol (lithic phases)	Engelmann spruce - subalpine fir closed & open forest (C15, O10), subalpine larch - subalpine fir forest (C23)

Fig. 14 Landscape schematic of the Copper (CP1) Ecosite in relation to other Ecosites.



MANAGEMENT CONSIDERATIONS

CP1 is of limited areal extent. Shallow soils and bedrock are the major factors to consider when planning park uses.

Table 40. Wildlife features of the CP1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
CP1	medium	bighorn sheep caribou	medium	weasel	low	heather vole	medium

CV - CONSOLATION VALLEY ECOSECTION

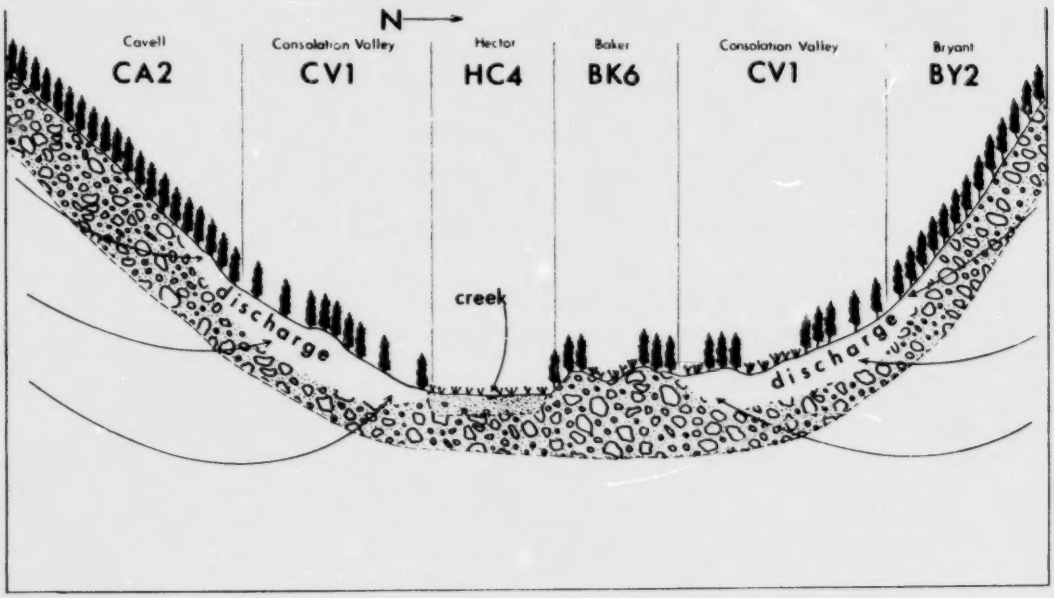
The Consolation Valley (CV) Ecosection encompasses a wet > dry landscape pattern on glacial landforms in the Lower Subalpine portion of the Subalpine Ecoregion. Wet (poorly to very poorly drained) segments are dominated by Gleysolic, gleyed Podzolic, and Organic soils under wet Engelmann spruce–subalpine fir open forest, wet spruce open forest, wet shrubby meadow, and birch fen vegetation. Dry (well to moderately well drained) segments are dominated by Brunisolic soils occurring under Engelmann spruce–subalpine fir or lodgepole pine forests. Features of the CV1 Ecosite are outlined in Table 41. Landscape position is shown in Fig. 15.

Table 41. General features of the CV1 Ecosite.

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
CV1	Inclined, hummocky, & ridged including bedrock control (blanket) > sloping fen	Till B (noncalcareous, medium textured) & low lime phase of Till C (calcareous, medium textured) > fen peat	Wet 80: Gleysol, gleyed Podzolic, Mesisol Dry 20: Eutric & Dystric Brunisol	Wet spruce open forest (O11), wet Engelmann spruce - subalpine fir open forest (O14) > wet shrubby meadow (S1), birch fen (S3). Engelmann spruce - subalpine fir forest (C13), lodgepole pine forest (C20, C29)

CV1 tracts occur in groundwater discharge areas, often on valley floors and lower valley wall slopes; seepage is characteristic. Other genetic materials that dominate a few CV1 tracts include Till A (noncalcareous, coarse textured), Ice Contact Stratified Drift B (calcareous, variably textured), and Ice Contact Stratified Drift A (noncalcareous, coarse textured). Postglacial slope failure is a common feature of CV1 landforms. Slopes commonly range from 5 to 45%. Surficial veneers of Eolian material B (altered, medium textured) and Fluviolacustrine material A (altered, fine-stratified) occur extensively in western Banff and southwestern Jasper.

Fig. 15 Landscape schematic of the Consolation Valley (CV1) Ecosite in relation to other Ecosites.



WILDLIFE

Table 42. Wildlife features of the CV1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
CV1	medium	moose	very high	coyote marten weasel wolverine	high	yellow pine chipmunk meadow vole porcupine	high

CV1 is highly important to wildlife. Although moose is the only ungulate to make much use of this Ecosite, many species of other mammals and birds occur here in large numbers.

MANAGEMENT CONSIDERATIONS

Poor to very poor drainage resulting from seepage and groundwater discharge limits most land uses unless expensive construction techniques are followed. Of particular consideration is the hydrologic importance of CV in maintaining and regulating stream flow.

Evidence of postglacial slope failure suggests that this may recur.

DV - DEVONA ECOSECTION

The Devona (DV) Ecosection encompasses ridged (dune) landforms of calcareous eolian material in the Montane Ecoregion in Jasper, in particular along the Athabasca River valley floor downstream from Jasper Lake. Regosolic soils are associated with white spruce forest or shrubby grassland. Two DV Ecosites are separated by vegetational differences (Table 43). Landscape position is shown in Fig. 16.

Table 43. General features of the DV Ecosites.

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
DV1	Ridged	Eolian material A (calcareous, medium textured).	Regosol	Shrubby grassland (L6).
DV2	Ridged	Eolian material A (calcareous, medium textured).	Regosol	White spruce forest (C27).

The eolian material is actively aggrading, particularly on DV1. Unvegetated blowouts are associated with active wind erosion. Slopes range from 5 to 30%. White spruce thickets occupy moist depressions between ridges on DV1. Soils are rapidly to well drained and extremely calcareous. Cumulic Regosols in the DV2 Ecosite indicate periods of geomorphic inactivity interspersed with periods of eolian deposition.

WILDLIFE

DV is very important to wildlife. In winter, it is critical range for deer and elk. Consequently, large carnivores are also concentrated adjacent to these grasslands. Some breeding birds occur here in high densities.

Fig 16 Landscape schematic of the Devona 1 (DV1) Ecosite in relation to other Ecosites.

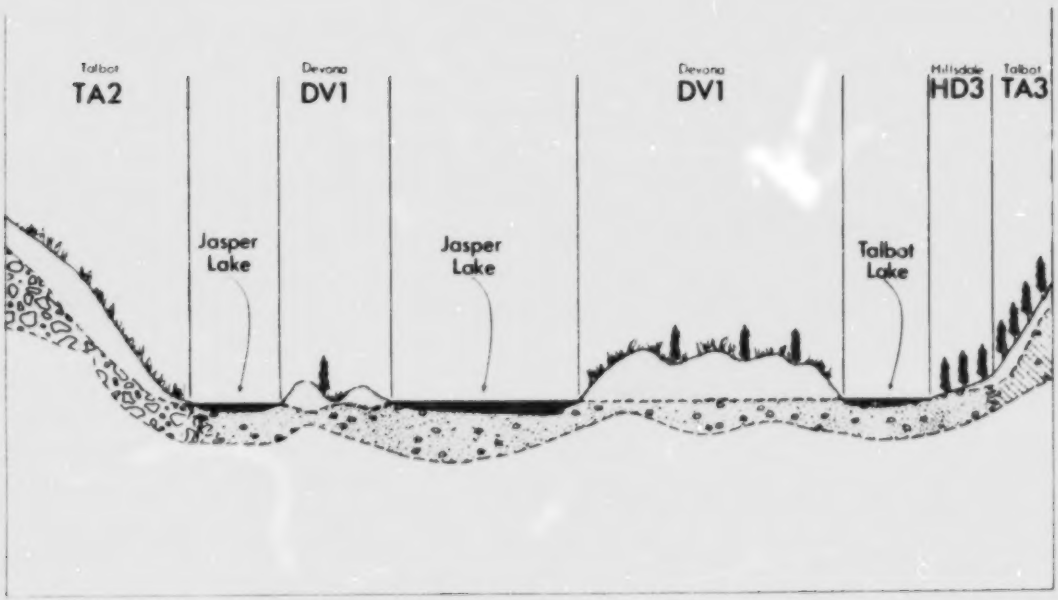


Table 44. Wildlife features of the DV Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
DV1	very high	elk deer	high	wolf weasel coyote lynx	medium	deer mouse	medium
DV2	very high	elk deer	high	wolf coyote cougar	high	deer mouse	high

DV1 and DV2 are of limited areal extent. Regosolic soils dominate and indicate current and recent eolian deposition. Removal of vegetation is likely to result in wind erosion. With disturbance, vegetation is easily removed and slow to recover. However, vegetation of DV2 is more resilient than that of DV1.

EF - EIFFEL ECOSECTION

The Eiffel (EF) Ecosection encompasses morainal landforms comprised of noncalcareous, coarse textured till within the Alpine Ecoregion. Dystric and Sombric Brunisols and Podzols characterize the soils. The vegetation is dominantly heath tundra. General features of the EF1 Ecosite are outlined in Table 45 and landscape position is shown in Fig. 21.

Table 45. General features of the EF1 Ecosite.

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
EF1	Blanket & veneer over inclined, hummocky and ridged bedrock	Till A (noncalcareous, coarse textured)	Dystric & Sombric Brunisol, Ferro-Humic Podzol	Heath tundra (L5)

EF1 occurs in the Main Ranges and is associated primarily with Gog Group strata. Surficial veneers of Eolian material B (altered, medium textured) occur on EF1 tracts in western Banff and southwestern Jasper. Podzolic soils are associated with these veneers. Slopes range from 5 to 45%. Soils are well drained. Lithic soil phases occur.

WILDLIFE

Table 46. Wildlife features of the EF1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
EF1	low	caribou mountain goat	low		medium	dusky shrew hoary marmot columbian ground squirrel golden-mantled ground squirrel heather vole	low

EF1 is of low importance to wildlife.

MANAGEMENT CONSIDERATIONS

Heath tundra vegetation is slow to recover from disturbances. Stony surfaces in some localities will affect trail and campsite construction.

EG - EGYPT ECOSECTION

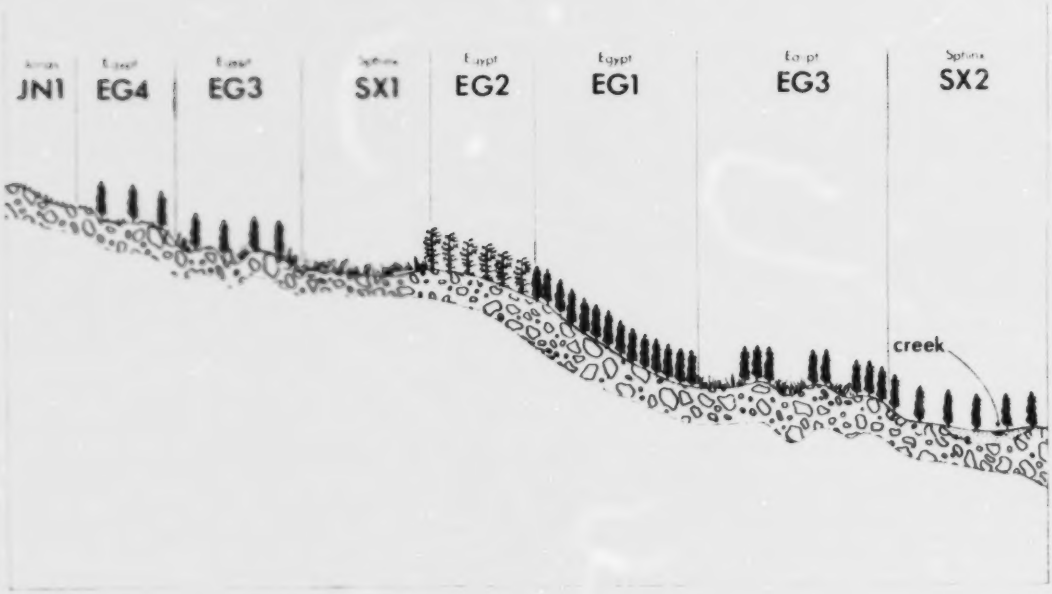
The Egypt (EG) Ecosection encompasses morainal landforms comprised of noncalcareous, medium textured till within the Upper Subalpine portion of the Subalpine Ecoregion. Dystric Brunisols are the dominant soils and occur under Engelmann spruce-subalpine fir closed and open forest, subalpine larch-subalpine fir forest, and a pattern of heath tundra plus coniferous open forest. The four EG Ecosites outlined in Table 47 are seperated by vegetational differences and a dry > wet landscape pattern. Landscape positions are shown on Fig. 17.

Table 47. General features of the EG Ecosites.

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
EG1	Blanket over inclined bedrock	Till B (noncalcareous, medium textured)	Dystric Brunisol	Engelmann spruce-subalpine fir closed & open forest (C15, C21, O10).
EG2	Blanket over inclined, hummocky, & ridged bedrock	Till B (noncalcareous, medium textured)	Dystric Brunisol > Humo-Ferric Podzol	Subalpine larch - subalpine fir forest (C23)
EG3	Blanket & veneer over hummocky & ridged bedrock	Till B (noncalcareous, medium textured)	Dry 70: Dystric Brunisol	Engelmann spruce - subalpine fir closed & open forest (C15,O10), subalpine larch-subalpine fir forest (C23)
			Wet 30: Gleysol, gleyed Podzolic, gleyed Brunisolic	Engelmann spruce - subalpine fir open forest (09), moist herb meadow (H16)
EG4	Blanket & veneer over inclined, hummocky & ridged bedrock	Till B (noncalcareous, medium textured)	Dystric Brunisol > Sombric Brunisol, Ferro-Humic Podzol	Heath tundra (L5) > Engelmann spruce - subalpine fir open forest (O10)

EG occurs in association with Miette Group strata in the Main Ranges, and with noncalcareous Mesozoic strata in the Front Ranges. Surficial veneers of Eolian material B

Fig 17 Landscape schematic of the Egypt (EG) Ecosites in relation to other Ecosites.



(altered, medium textured) occur extensively in western Banff and southwestern Jasper. The subdominant and accessory Podzolic soils are associated with these veneers. Slopes range from 15 to 70% for EG1 and EG4, and from 5 to 45% for EG2 and EG3. Soils are well to moderately well drained except for the wet depressional segments of EG3 which are imperfectly to poorly drained. Occurrences of subalpine larch-subalpine fir forest are restricted to southern Banff.

A few EG3 tracts occur on landforms dominated by Till A (noncalcareous, coarse textured). Depressional segments of some EG3 tracts consist of Fluvial material A (noncalcareous, coarse-stratified). Lithic soil phases are important on EG3 and EG4; turbic soil phases on EG4.

WILDLIFE

EG is moderately important to wildlife. The mosaic of habitats often supports a wide variety of small mammal species, but the deep snow precludes much use by ungulates and carnivores in winter.

Table 48. Wildlife features of the EG Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
EG1	medium	moose elk	high	coyote	medium	muskrat snowshoe hare golden-mantled ground squirrel red-backed vole porcupine	low
EG2	high	elk moose	high	marten	medium	heather vole	low
EG3	low	moose	medium	marten	medium	northern bog lemming	medium
EG4	low	caribou	low		low	heather vole	medium

MANAGEMENT CONSIDERATIONS

On EG1, steepness of slope is a major factor to consider in planning park uses. Locally occurring avalanche paths and, less often, seeps will affect certain uses. EG2 is similar to EG1 in its management concerns but is of limited areal extent. Eolian material B veneers are common on EG2 and tend to erode easily where vegetation is removed. Dry portions of EG3 have no limitations other than those mentioned above. However, the dry > wet landscape pattern requires special consideration in location and design when planning some uses, e.g. trail construction. EG4 is similar to EG1 in its management concerns but its heath tundra vegetation is slow to recover from disturbances.

EN - ENDLESS CHAIN

The Endless Chain (EN) Ecosection encompasses inclined landforms of noncalcareous, coarse textured colluvium in the Upper Subalpine portion of the Subalpine Ecoregion. It is dominated by Dystric Brunisols occurring under Engelmann spruce–subalpine fir closed and open forest, mixed coniferous open forest, and an avalanche complex of v.t.s. Vegetational differences are the main criteria separating the three EN Ecosites (Table 49). Landscape positions are shown in Fig. 18.

EN occurs primarily in the Main Ranges on or below steep, rocky, valley walls in areas dominated by Gog Group strata. Surficial veneers of Eolian material B (altered, medium textured) occur sporadically. Slopes commonly range from 45 to 100%. Soils are rapidly to well drained. Avalanche paths characteristically occupy more than 50% of EN2. Unvegetated portions may constitute up to 50% of EN2 and EN3 tracts. EN3 is the steepest of three EN Ecosites and has the greatest abundance of lithic soils and rock outcrops. Avalanche Complex 2, for EN2, is a heterogeneous complex of v.t.s. that includes subalpine fir–willow (S2), willow–dwarf birch–shrubby cinquefoil (S10), juniper–willow (L2), hairy wild rye – wild strawberry –fireweed (H5), fleabane–valerian (H16), plus intergrades, with S2 being most abundant.

Table 49. General features of the EN Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
EN1	Blanket & veneer over inclined bedrock	Collovium A (noncalcareous, coarse textured)	Dystric Brunisol	Engelmann spruce - subalpine fir closed & open forest (C15, C21, O10)
EN2	Blanket & veneer over inclined bedrock, apron	Colluvium A (noncalcareous, coarse textured)	Dystric Brunisol > Regosol	Avalanche Complex 2 > mixed coniferous open forest (O4) > Engelmann spruce subalpine fir open forest (O10)
EN3	Blanket & veneer over inclined bedrock > inclined bedrock	Colluvium A (noncalcareous, coarse textured)	Dystric Brunisol > Regosol	Mixed coniferous open forest (O4) > Engelmann spruce - subalpine fir open forest (O10)

Fig. 18 Landscape schematic of the Endless Chain Ecosites in relation to other Ecosites.

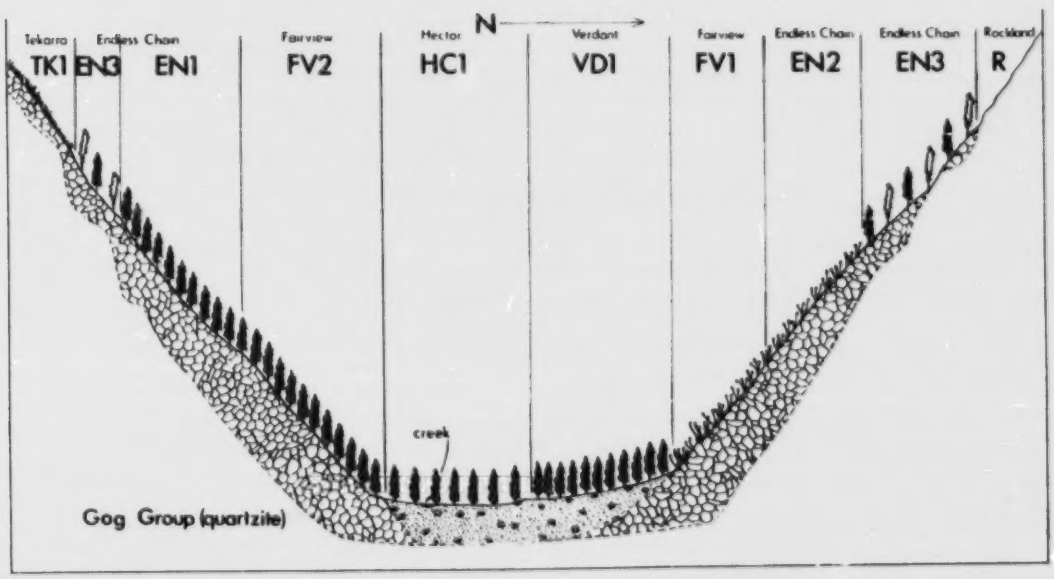


Table 50. Wildlife features of the EN Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
EN1	medium	mountain goat	low		medium		low
EN2	medium	mountain goat	low		medium	meadow vole western jumping mouse	low
EN3	medium	deer elk	low	wolf coyote	low	snowshoe hare	low

This steep Ecosection is of low importance to wildlife, although EN1 and EN2 are highly important to goats.

MANAGEMENT CONSIDERATIONS

Steep and locally unstable (colluviating) slopes are limiting factors to be considered for many park uses. Stony surfaces, shallow soils, and bedrock outcrops affect planning for uses such as trails, especially on EN3. Snow avalanching, whether local (on EN1, EN3) or extensive (EN2), will affect winter uses. EN1 is of limited areal extent. Vegetation on EN3 is expected to recover slowly from disturbances.

FR - FIRESIDE ECOSECTION

The Fireside (FR) Ecosection (Table 51) consists of fluvial landforms dominated by Brunisolic soils and lodgepole pine forest within the Montane Ecoregion. The FR Ecosection occurs primarily on lower slopes and floors of valleys.

Table 51. General features of the FR1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
FR1	Fan & apron	Fluvial material B, (calcareous, coarse-stratified)	Eutric Brunisol	Lodgepole pine forest (C6, C19)

FR1 includes landforms comprised of Fluvial material A (noncalcareous, coarse-stratified) in the Miette River valley in Jasper. Surfaces are often channeled. Slopes range from 2 to 30%. Soils are well drained. Regosolic soils occur in narrow strips along present and recently abandoned stream channels. Lodgepole pine/dwarf

bilberry (C9) is common on FR1 tracts located in southern Banff.

WILDLIFE

Table 52. Wildlife features of the FR1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
FR1	high	deer elk moose	high	coyote wolf cougar lynx	high	snowshoe hare red squirrel beaver deer mice red-backed vole heather vole	high

FR1 is highly important to wildlife. Many species occur here in large numbers. Ungulates are most abundant in winter. The lush ground cover also supports many species of small mammals and breeding birds.

MANAGEMENT CONSIDERATIONS

FR1 tracts with gentle slopes generally have no characteristics limiting uses for campgrounds, trails, or other related park uses. Locally occurring coarse textures and high water tables may present problems for sewage disposal. Coarse textured materials provide gravel for construction purposes.

EACH TRACT SHOULD BE EVALUATED FOR SPECIFIC PROPOSED USES.

FV - FAIRVIEW ECOSECTION

The Fairview (FV) Ecosection encompasses inclined landforms composed of noncalcareous, colluvial materials in the Lower Subalpine portion of the Subalpine Ecoregion. It is dominated by Dystric Brunisols occurring under Engelmann spruce–subalpine fir forest and an avalanche complex of v.t.s. Table 53 outlines two FV Ecosites separated by vegetational differences. Landscape positions are shown in Fig. 18.

FV occurs primarily in the Main Ranges on or below steep valley walls and is associated with noncalcareous bedrock. Surface veneers of Eolian material B (altered, medium textured) occur sporadically. Slopes commonly range from 45 to 90%. Soils are rapidly to moderately well drained. Snow avalanch paths characteristically occupy more than 50% of FV1. Unvegetated portions may constitute up to 50% of FV1 tracts. Avalanche Complex 1, for FV 1, is a heterogeneous complex of v.t.s. that includes subalpine fir–willow (S2), willow–dwarf birch–shrubby cinquefoil (SI0), hairy wild rye – wild strawberry – fireweed (H5), aspen / hairy wild rye – showy aster (C22), plus intergrades, with S2 being most abundant.

Table 53. General features of the FV Ecosites.

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
FV1	Blanket & veneer over inclined bedrock, apron	Colluvium A (noncalcareous, coarse textured + Colluvium B (noncalcareous, medium textured)	Dystric Brunisol > Regosol	Avalanche Complex 1 > Engelmann spruce - subalpine fir forest (C13, C14)
FV2	Blanket over inclined bedrock, apron	Colluvium A (noncalcareous, coarse textured) + Colluvium B (noncalcareous, medium textured)	Dystric Brunisol	Engelmann spruce-subalpine fir forest (C13, C14, C21)

WILDLIFE

Table 54. Wildlife features of the FV Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
FV1	low		medium	weasel wolverine	medium	masked shrew pika golden-mantled ground squirrel western jumping mouse	high
FV2	medium		low		medium	red-backed vole	medium

FV is moderately important to wildlife, especially small mammals and birds.

MANAGEMENT CONSIDERATIONS

Steep and locally unstable (colluviating) slopes are limiting factors to be considered for many park uses. Stony surfaces will affect planning for uses such as trails. Snow avalanching, whether local (on FV2) or extensive (FV1), will affect winter uses.

GA - GARONNE ECOSECTION

The Garonne (GA) Ecosection encompasses hummocky landslide deposits in the Montane Ecoregion. It is dominated by Brunisolic and Regosolic soils and lodgepole pine forest. The general features of the GA1 Ecosite are outlined in Table 55.

Table 55. General features of the GA1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
GA1	Hummocky	Landlside material (calcareous, medium textured)	Eutric Brunisol, Regosol	Lodgepole pine forest (C3, C6, C19)

Surficial veneers of Eolian material A (calcareous, medium textured) overlie the landslide material in Jasper and veneers of Eolian material B (altered, medium textured) overlie landslide material in Banff. Complex slopes range from 15 to 45%. Soils are rapidly to well drained. Rubbly, blocky surfaces occur locally.

WILDLIFE

Table 56. Wildlife features of the GA1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
GA1	high	deer elk	high	wolf coyote cougar	medium		high

GA is highly important to wildlife. The varied topography, vegetation and low elevation contribute to its importance to many species of ungulates, carnivores and birds.

MANAGEMENT CONSIDERATIONS

GA1 is of very limited areal extent. Irregular topography, often with moderate to steep slopes, and sites with rubbly, blocky surfaces are limiting for park uses such as campgrounds and may affect the design of trails and roads.

GT - GOAT ECOSECTION

The Goat (GT) Ecosection encompasses calcareous, morainal landforms dominated by a Brunisolic > Regosolic soil pattern within the Lower Subalpine portion of the Subalpine Ecoregion. Vegetation is characterized by lodgepole pine forest, white spruce open forest, mixed coniferous open forest, dry grassland, and low shrub-herb meadow. Table 57 outlines two GT Ecosites differentiated by patterns of soils and vegetation. Landscape positions are shown in Figs. 19 and 29.

Table 57. General features of the GT Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
GT1	Blanket over inclined bedrock	Till C (calcareous, medium textured)	Eutric Brunisol > Regosol	Lodgepole pine forest (C3), mixed coniferous open forest (O4), white spruce open forest (O17)
GT2	Blanket over inclined & ridged bedrock, inclined	Till C (calcareous, medium textured)	Northerly: Eutric Brunisol Southerly: Eutric Brunisol, Humic Regosol	Lodgepole pine forest (C6, C19) Dry grassland (H14), low shrub-herb meadow (L1)

GT1 occurs on valley walls primarily with southerly aspects. Soil and vegetation patterns reflect surface erosional processes including gullying, sheet erosion, and soil creep. Slopes range from 45 to 70%. Soils are rapidly to well drained. GT2 occurs in the Front Ranges, usually in association with Mesozoic strata. Surface expression reflects stream incisions on valley floors and bedrock control on valley walls and benchlands. Some GT2 tracts on river banks include Ice Contact Stratified Drift B (calcareous, variably textured). Slopes range from 30 to 90%. GT2 soils and vegetation are distributed in a pattern governed by aspect, steepness of slope, exposure, and erosional processes. Stable positions of the landscape, collectively labelled "northerly aspect" segments, are dominated by well drained Brunisolic soils under lodgepole pine forest. Eroding or recently eroded portions of the landscape, collectively labelled "southerly aspect" segments, have rapidly drained Brunisolic and Regosolic soils under grassland and shrub-herb meadow vegetation.

WILDLIFE

GT is very important to wildlife except birds. Dry, southerly, exposed slopes with grasslands are important foraging areas for ungulates and small mammals. Carnivores are attracted here by the abundant prey.

Fig. 19 Landscape schematic of the Goat Ecosites in relation to other Ecosites.

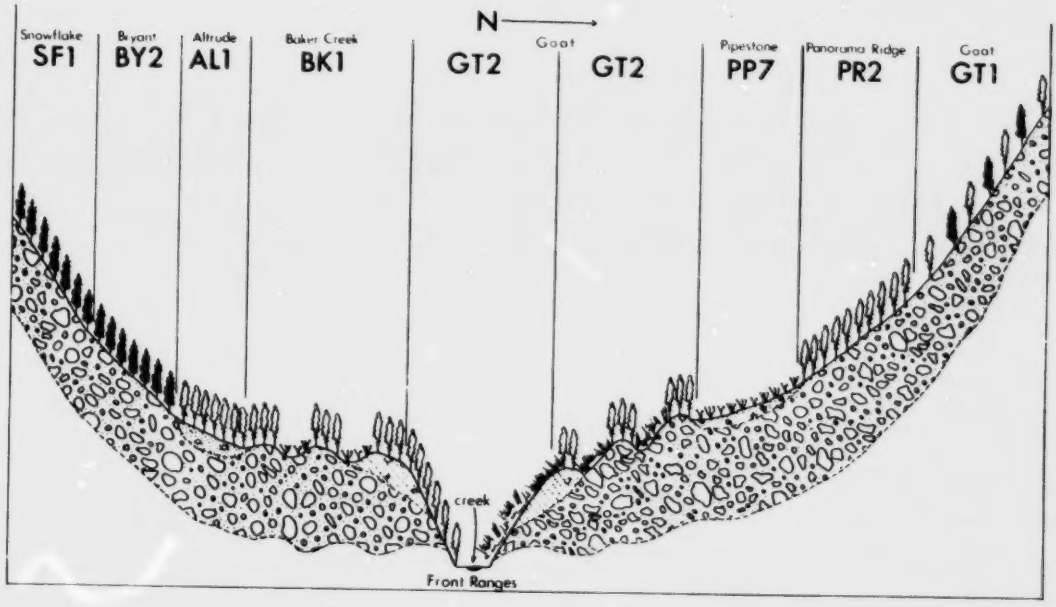


Table 58. Wildlife features of the GT Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
GT1	high	elk bighorn sheep mountain goat deer	very high	cougar wolf coyote	medium	masked shrew heather vole	low
GT2	very high	elk deer mountain goat	very high	wolf coyote cougar lynx	very high	snowshoe hare least chipmunk columbian ground squirrel deer mice northern bog lemming meadow vole	medium

MANAGEMENT CONSIDERATIONS

Steep and locally eroding slopes are limiting factors to be considered for many park uses of GT1 and GT2. On GT2 tracts, moderately sloping, forested portions are not limiting for trails and related park uses, but removal of vegetation on nonforested portions would increase erosion significantly. Nonforest vegetation is likely to recover slowly from disturbances.

HC - HECTOR ECOSECTION

The Hector (HC) Ecosection encompasses wet fluvial and fluviolacustrine landforms on valley floors in the Lower Subalpine portion of the Subalpine Ecoregion. A complex set of genetically related Gleysolic, Gleyed Regosolic, and Organic soils occur. Various groupings of Engelmann spruce forest, Engelmann spruce - subalpine fir open forest, wet shrubby meadow, birch fen, wet shrub thicket, and sedge fen differentiate the three HC Ecosites outlined in Table 59. Landscape positions are shown in Figs. 11, 15, 18, and 29.

Table 59. General features of the HC Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
HC1	Level, apron, fan > horizontal fen	Fluvial material A & B (noncalcareous & calcareous, coarse-stratified) > fen peat	Gleysol > gleyed Regosolic, Mesisol	Moist Engelmann spruce forest (C32), wet Engelmann spruce-subalpine fir open forest (O6) > wet shrubby meadow (S1), birch fen (S3)
HC2	Level	Fluviolacustrine material B (calcareous, fine-stratified)	Gleysol	Sedge fen (H11)
HC4	Level, apron, fan > horizontal fen	Fluvial materials A & B (noncalcareous & calcareous, coarse-stratified) > fen peat	Gleysol > gleyed Regoslic, Mesisol	Wet shrubby meadow (S1), birch fen (S3), wet shrub thicket (S11), sedge fen (H11)

Wetness on HC results from high water tables, seepage, and groundwater discharge and gives imperfectly to very poorly drained soils. Fluviolacustrine deposits are important accessory materials on HC1 and HC4. Soils in active or recently active sedimentation environments lack surface peat layers, whereas soils of geomorphically inactive localities have surface organic layers and include Mesisols on horizontal fens in ponded localities. Active siltation from ponded, glacial streams characterizes most HC2 tracts, hence surface peat layers are absent and a bryoid-poor variant of the H11 v.t. is dominant. Slopes are often channeled and range from 0 to 9% on HC1 and HC4, 0 to 1% on HC2.

Table 60. Wildlife features of the HC Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
HC1	medium	moose	high	wolverine wolf coyote	medium	masked shrew dusky shrew western jumping mouse	high
HC2	low		medium	weasel	low	beavers northern bog lemming meadow vole porcupine	high
HC4	high	moose elk caribou	high	weasel cougar wolf coyote	medium		high

HC is highly important to wildlife, especially birds. Ecosites with open or no forest cover are the most important. The shrub and sedge meadows are highly important moose habitat. The willow meadows are critical winter habitat for White-tailed Ptarmigan.

MANAGEMENT CONSIDERATIONS

Imperfect to very poor drainage, resulting from high water tables and local flooding, severely limits most park uses unless expensive construction techniques are followed. On some tracts, particularly on the very poorly drained HC2 Ecosites, sediment deposition accompanies flooding. Major construction activities (e.g. roads) will change sedimentation and erosional patterns. HC2 is of limited areal extent.

EACH TRACT SHOULD BE EVALUATED IN DETAIL FOR SPECIFIC PROPOSED USES.

HD - HILLSDALE ECOSECTION

The Hillsdale Ecosection encompasses fluvial landforms dominated by Regosolic soils in the Montane Ecoregion. Various vegetational groupings involving aspen, white spruce, lodgepole pine, and white spruce-Douglas fir forests and grassland differentiate the four HD Ecosites outlined in Table 61.

HD occurs on lower slopes and valley floors. Channeled surfaces are common. Surficial veneers of Eolian material A (calcareous, medium textured) occur north of Jasper Lake . Tracts mapped in the Miette River valley in Jasper are comprised of Fluvial material A (noncalcareous, coarse-stratified). Slopes range from 1 to 15%. Soils are rapidly to moderately well drained; gleyed soils with imperfect drainage occur on the

Table 61 General features of the HD Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
HD1	Fan, apron	Fluvial material B (calcareous, coarse-stratified)	Regosol	Aspen forest (C16)
HD2	Fan, level, apron	Fluvial material B (calcareous, coarse-stratified)	Regosol	Spruce open forest (O3)
HD3	Fan, apron	Fluvial material B (calcareous, coarse-stratified)	Regosol	White spruce forest (C2, C26, C27), white spruce-Douglas fir forest (C5)
HD4	Fan, apron	Fluvial material B (calcareous, coarse-stratified)	Regosol	Grassland (H6) - lodgepole pine forest (C3)

toes of fans and aprons.

WILDLIFE

This Montane Ecosection is very important to wildlife. Critical range for elk and deer occurs here. High densities of small mammals, birds and some carnivores were recorded on all Ecosites. HD has low snow accumulation and palatable forage which contribute to its importance to ungulates.

MANAGEMENT CONSIDERATIONS

Fluvial deposition is sufficiently frequent to maintain the dominantly Regosolic soils and is a major factor to consider in planning of park uses. Locally occurring coarse textures and high water tables present problems for sewage disposal. The coarse textured material provides gravel for construction purposes. HD4 is of limited areal extent. It is also particularly droughty and problems in revegetation are likely to occur.

EACH TRACT SHOULD BE EVALUATED IN DETAIL FOR SPECIFIC PROPOSED USES.

HE - HEATHER ECOSECTION

The Heather (HE) Ecosection encompasses residual and bedrock landforms in the Alpine Ecoregion. Lithic phases of Brunisolic and Regosolic soils dominate areas where soil is present, but areas of nonsoil (surface veneers <10 cm thick over bedrock) are common. Mountain avens tundra dominates most HE tracts. Table 63 outlines the features of the two HE Ecosites differentiated by consolidated versus unconsolidated bedrock and resultant effects on soil and vegetation.

HE occurs at high elevations on cols, plateaus, rounded mountain peaks and ridges, and

Table 62 Wildlife features of the HD Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
HD1	high	elk deer	high	coyote cougar marten wolf	high	columbian ground squirrel red squirrel meadow vole	high
HD2	very high	elk deer	high	wolf coyote lynx cougar	very high	masked shrew snowshoe hare red squirrel deer mice	high
HD3	high	deer moose	high	wolf coyote cougar lynx	high	snowshoe hare least chipmunk deer mice	high
HD4	very high	elk deer bighorn sheep	high	wolf cougar	high	red squirrel deer mice	high

Table 63 General features of the HE Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
HE1	Inclined, hummocky, ridged	Residuum A & B (noncalcareous + calcareous, medium textured)	Sombric + Melanic Brunisol, Humic Regosol (lithic phases)	Mountain avens tundra (H1)
HE2	Ridged bedrock > veneer over ridged + hummocky, bedrock	Calcareous bedrock > Residuum B (calcareous, medium textured)	Nonsoil >> Melanic Brunisol, Humic Regosol (lithic phases)	Unvegetated portions > mountain avens tundra (H1)

in cirques. HE1 occurs most often on Miette strata in the Main Ranges and Mesozoic strata in the Front Ranges; HE2 usually occurs on resistant carbonate strata in the Main Ranges. Slopes range up to 45% on HE1 and from 5 to 70% on HE2. Solifluction with turbic soil phases is common on HE1. Bedrock is the dominant feature of HE2 and vegetation is more extensive than soil.

Table 64. Wildlife features of the HE Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
HE1	medium	bighorn sheep mountain goat	low	weasel	medium	pika columbian ground squirrel golden-mantled ground squirrel	low
HE2	medium	bighorn sheep mountain goat	low		low	golden-mantled ground squirrel	low

HE is of low importance to all wildlife except sheep and goat which forage here intensively.

MANAGEMENT CONSIDERATIONS

Bedrock and shallow soils are major considerations in planning park uses of the HE Ecosection. Solifluction and cryoturbation are common on some HE1 tracts. Vegetation is expected to recover slowly from disturbances. HE2 is of slightly different concern than HE1, especially since rockiness is the salient feature and excludes those uses requiring unconsolidated materials, e.g. in trail building. Vegetation on HE2 is expected to recover very slowly from disturbances. Wet sites make up only a small portion of HE2 but are lushly vegetated and conspicuous. It is expected that these small wet sites can be easily damaged.

IB - ISHBEL ECOSECTION

The Ishbel (IB) Ecosection encompasses hummocky landslide deposits in the Lower Subalpine portion of the Subalpine Ecoregion. Brunisolic and Regosolic soils are associated with lodgepole pine forest, coniferous open forest, and Engelmann spruce-subalpine fir forest. Table 65 outlines the features of three IB Ecosites that are seperated primarily by vegetational differences. Landscape position is shown in Fig. 10.

IB occurs on mid to lower valley wall positions. Surfaces are often stony and bouldery. Veneers of Eolian material B (altered, medium textured) are common on IB1 and IB3 tracts in western Banff and southwestern Jasper. Soils are rapidly to well drained; Eutric Brunisols occur on calcareous materials, Dystric Brunisols on noncalcareous materials. Unvegetated portions may constitute up to 50% of IB2 tracts.

Table 65. General features of the IB Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
IB1	Hummocky	Landslide material (calcareous + noncalcareous, variably textured)	Eutric & Dystric Brunisol	Lodgepole pine forest (C18, C19, C29)
IB2	Hummocky	Landslide material (calcareous & noncalcareous, variably textured)	Regosol, Eutric + Dystric Brunisol	Mixed coniferous open forest (O4), spruce open forest (O17)
IB3	Hummocky	Landslide material (calcareous + noncalcareous, variably textured)	Eutric & Dystric Brunisol	Engelmann spruce - subalpine fir forest (C21, C30)

WILDLIFE

Table 66. Wildlife features of the IB Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
IB1	medium		medium	wolf	high	red-backed vole	medium
IB2	low		medium	wolverine	medium	pika red squirrel	medium
IB3	low	moose	medium	lynx cougar	low	masked shrew snowshoe hare	medium

IB is moderately important to wildlife. The wildlife is typical of much of the subalpine forests.

MANAGEMENT CONSIDERATIONS

Irregular topography, often with moderate to steep slopes, and sites with rubbly, blocky surfaces are limiting for campgrounds and related uses and can affect the design of trails and roads. Vegetation on IB2 is expected to recover slowly from disturbances, including fire.

JN - JONAS ECOSECTION

The Jonas (JN) Ecosection encompasses morainal landforms consisting of noncalcareous, medium textured till in the Alpine Ecoregion. A soil pattern of Dystric and Sombric Brunisols and Podzolics occurs under heath and mountain avens tundra. Table 67 summarizes characteristics of the JN1 Ecosite. Landscape position is shown in Fig. 17.

Table 67. General features of the JN1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
JN1	Blanket & veneer over inclined, hummocky, & ridged bedrock	Till B (noncalcareous, medium textured)	Dystric & Sombric Brunisol > Ferro-Humic Podzol	Heath tundra (L5), mountain avens tundra (H1)

JN1 occurs on valley walls and shoulders and in cirque basins and cols. Veneers of Eolian material B (altered, medium textured) occur extensively in western Banff and southwestern Jasper, sporadically elsewhere. Podzolic soil occurrences are associated with these veneers. Slopes range from 5 to 45%. Soils are well to moderately well drained. Solifluction and cryoturbation are common surface modifiers. Lithic and turbic soil phases occur. Heath tundra (L5) vegetation is most abundant.

WILDLIFE

Table 68. Wildlife features of the JN1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
JN1	medium	caribou bighorn sheep mountain goat	low		low	pika hoary marmot columbian ground squirrel golden-mantled ground squirrel	low

JN1 is of low importance to wildlife except some ungulates and small mammals. Sheep and goat occur in high numbers.

MANAGEMENT CONSIDERATIONS

An intricate pattern of soils and vegetation, related to drainage conditions, necessitates detailed evaluation of individual tracts for planning of park uses. Of particular concern are imperfectly to poorly drained and soliflucted sites. Vegetation is expected to recover slowly from disturbances.

KA - KATHERINE ECOSECTION

The Katherine (KA) Ecosection (Table 69) encompasses fluvial apron and fan landforms in the Alpine Ecoregion. Regosolic and Gleysolic soils occur under dwarf shrub-herb meadow and mountain avens tundra. Landscape position is shown in Fig. 20.

Table 69. General features of the KA1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
KA1	Fan, apron	Fluvial materials A & B (noncalcareous & calcareous, coarse-stratified)	Humic Regosol, Gleysol	Dwarf shrub-herb meadow (L7), mountain avens tundra (H1)

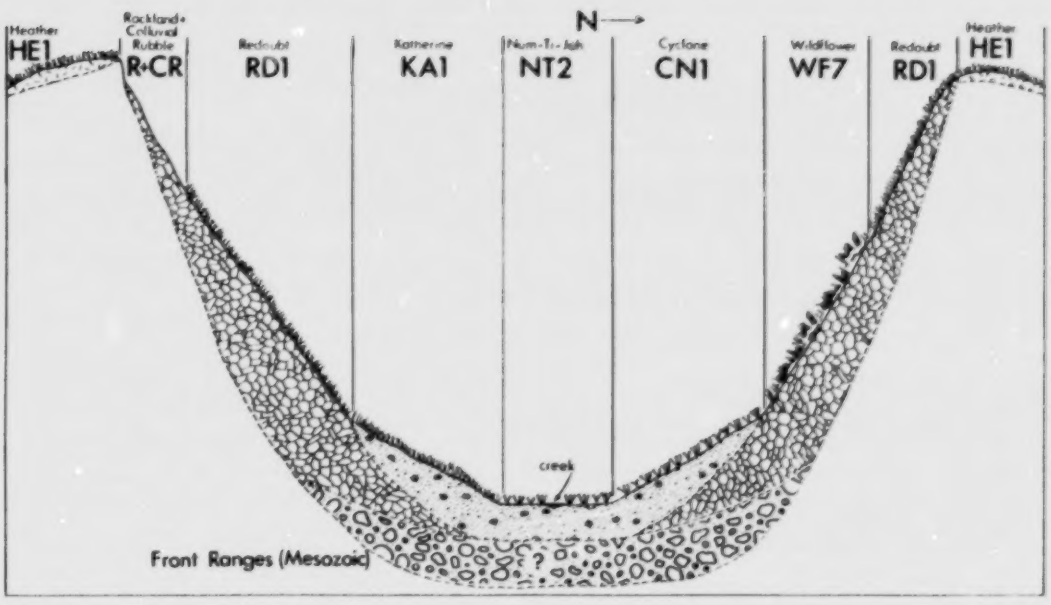
KA is most extensive in the Front Ranges and occurs on lower valley wall slopes and valley floors. Variable seepage conditions related to snow melt and soil thaw on slopes above KA maintain its moist to wet conditions (i.e. moderately well to poorly drained soils). Stratified deposits, including interbedded and mixed humus, are manifestations of episodic fluvial deposition and mixing by solifluction. Slopes range from 1 to 30% and are often channeled and soliflucted.

WILDLIFE

Table 70. Wildlife features of the KA1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
KA1	high	bighorn sheep moose elk	low		low		low

Fig. 20 Landscape schematic of the Katherine 1 (KA1) Ecosite in relation to other Ecosites.



KA1 is of low importance to wildlife overall, but highly important to sheep, moose and elk in summer. The wet alpine meadows provide summer forage for these ungulates.

MANAGEMENT CONSIDERATIONS

An intricate pattern of soils and vegetation, related to drainage and solifluction, necessitates detailed evaluation of individual tracts for trails, campgrounds, or other park uses. Of particular concern are imperfectly to poorly drained and soliflucted localities. The soils lack B horizons, suggesting that geomorphic activity or wetness are sufficiently great to maintain these weakly developed soils. Vegetation is expected to recover slowly from disturbances.

LV - LARCH VALLEY ECOSECTION

The Larch Valley (LV) Ecosection encompasses morainal landforms comprised of non-calcareous, coarse textured till in the Upper Subalpine portion of the Subalpine Ecoregion. A Brunisolic > Podzolic soil complex dominates and occurs under subalpine larch-subalpine fir forest, Engelmann spruce-subalpine fir closed and open forest, and a distinctive pattern of heath tundra plus coniferous open forest. These vegetational differences separate the three LV Ecosites (Table 71). Landscape positions are shown in Fig. 21.

Table 71. General features of the LV Ecosite

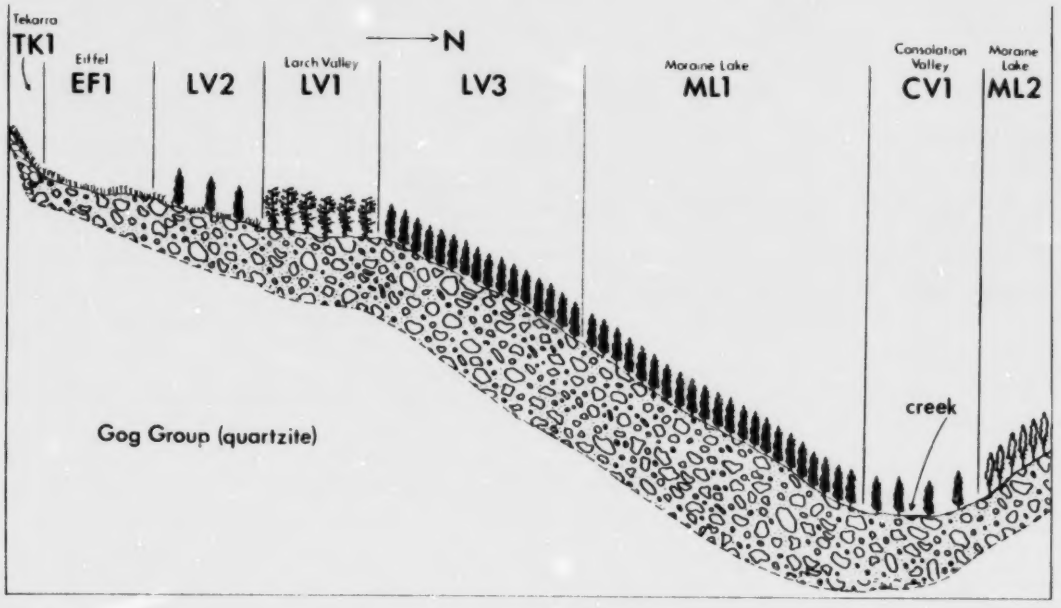
Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
LV1	Blanket over inclined, hummocky & ridged bedrock	Till A (noncalcareous, coarse textured)	Dystric Brunisol > Humo-Ferric Podzol	Subalpine larch - subalpine fir forest (C23)
LV2	Blanket, veneer over inclined, hummocky & ridged bedrock	Till A (noncalcareous, coarse textured)	Dystric Brunisol > Sombric Brunisol, Ferro-Humic Podzol	Heath tundra (L5) > Engelmann spruce - subalpine fir open forest (O10)
LV3	Blanket over inclined bedrock	Till A (noncalcareous, coarse textured)	Dystric Brunisol > Humo-Ferric Podzol	Engelmann spruce - subalpine fir closed and open forest (C15, C21, O10)

Table 72. Wildlife features of the LV Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
LV1	low	moose	low	wolf	medium	least chipmunk heather vole long-tailed vole western jumping mouse	low
LV2	low		low	weasel	medium	hoary marmots columbian ground squirrel heather vole porcupine	low
LV3	medium	mountain goat caribou	medium	marten wolverine	low	dusky shrew pika columbian ground squirrel heather vole porcupine	medium

LV occurs primarily on valley walls and shoulders, cirque basins, and cols. It occurs in the Main Ranges in areas dominated by Gog Group quartzites. Veneers of Eolian material B (altered, medium textured) occur extensively in western Banff and southwestern Jasper; the subdominant Podzolic soils are associated with these veneers. Slopes range from 15 to 70%; soils are well drained. Occurrences of subalpine larch-subalpine fir forest (C23) are restricted to southern Banff. Lithic soil phases are important on tracts mapped as LV2.

Fig. 21 Landscape schematic of the Larch Valley (LV) Ecosites in relation to other Ecosites.



WILDLIFE

LV is moderately important to wildlife, particularly small mammals which occur in high numbers here. LV3 is also important to goat and caribou in the summer.

MANAGEMENT CONSIDERATIONS

All three of the LV Ecosites have similar management concerns, except that LV1 is of limited areal extent. Steepness of slope is the major factor in planning park uses, but coarse textures may also influence certain uses. The eolian veneers, common in many areas, tend to erode easily where vegetation is removed. Locally occurring avalanche paths will affect certain uses. Heath tundra vegetation on LV2 is slow to recover from disturbances.

MC - MERLIN CASTLE ECOSECTION

The Merlin Castle (MC) Ecosection encompasses a wet > dry landscape pattern on glaciolacustrine landforms in the Lower Subalpine portion of the Subalpine Ecoregion. Wet (poorly drained) segments are dominated by Gleysolic and gleyed Brunisolic soils

under wet spruce open forest and birch fen. Dry (well to moderately well drained) segments are dominated by Luvisolic and Brunisolic soils under lodgepole pine and Engelmann spruce-subalpine fir forests. Table 73 outlines the features of the MC1 Ecosite.

MC1 occupies valley floor benchland positions. Wetness is attributed to seepage and surface water accumulation. Veneers of fen peat, Fluviolacustrine material A (altered, fine-stratified), and Eolian material B (altered, medium textured) occur locally. Slopes range from 0 to 10%.

WILDLIFE

MC1 is of low importance to wildlife.

MANAGEMENT CONSIDERATIONS

Poor drainage, resulting from surface water collection on slowly pervious, fine textured, glaciolacustrine material, severely limits most park uses unless expensive construction techniques are followed.

Table 73. General features of the MC1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
MC1	Glaciolacustrine veneer & blanket over ridged, hummocky, & undulating glacial materials	Glaciolacustrine material (calcareous, fine textured) over Ice contact stratified Drift A & B (non-calcareous, coarse textured & calcareous, variably textured)	Wet 80: Gleysol, Gleyed Eutric Brunisol Dry 20: Gray Luvisol, Eutric Brunisol	Spruce open forest (O11), birch fen (S3) Lodgepole pine forest (C29) Engelmann spruce-subalpine fir forest (C30)

Table 74. Wildlife features of the MC1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
MC1	low	moose	medium		low		low

ML - MORAINE LAKE ECOSECTION

The Moraine Lake (ML) Ecosection encompasses morainal landforms comprised of noncalcareous, coarse textured till in the Lower Subalpine portion of the Subalpine Ecoregion. Dystric Brunisols are the dominant soils. Vegetation is dominated by Engelmann spruce–subalpine fir forest, lodgepole pine forest, and Engelmann spruce–whitebark pine forest. Table 75 summarizes three ML Ecosites distinguished by vegetational differences. Landscape position is shown in Fig. 21.

Table 75. General features of the ML Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
ML1	Blanket over inclined bedrock	Till A (noncalcareous, coarse textured)	Dystric Brunisol > Humo-Ferric Podzol	Engelmann spruce - subalpine fir forest (C13, C14, C21)
ML2	Blanket over inclined bedrock	Till A (noncalcareous, coarse textured)	Dystric Brunisol	Lodgepole pine forest (C18, C20)
ML3	Blanket over inclined bedrock	Till A (noncalcareous, coarse textured)	Dystric Brunisol	Engelmann spruce - white bark pine forest (C12)

ML occurs primarily on valley walls in the Main Ranges and is associated with Gog Group quartzites. Veneers of Eolian material B (altered, medium textured) occur extensively in western Banff and southwestern Jasper, sporadically elsewhere. Podzolic soils are associated with the eolian veneers. Slopes range from 15 to 70% and are often gullied; soils are well drained. ML3 occurs only in Jasper.

WILDLIFE

ML is highly important to wildlife, especially small mammals and birds. The moist coniferous forests support a high concentration of many species of small mammals and birds.

MANAGEMENT CONSIDERATIONS

Steepness of slope is the major factor in planning park uses, but coarse textures and high coarse fragment content may also influence certain uses. Eolian material B veneers are extensive on many ML1 tracts and tend to erode easily where vegetation is removed. Locally occurring avalanche paths will affect certain uses. ML3 is of limited areal extent.

Table 76. Wildlife features of the ML Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
ML1	low	moose	medium		very high	pika least chipmunk yellow pine chipmunk golden-mantled ground squirrel red-backed vole heather vole western jumping mouse porcupine	high
ML2	low	moose	low		high	red squirrel deer mouse red-backed vole heather vole	medium
ML3	medium	deer caribou	medium	wolf marten cougar	high	yellow pine chipmunk red squirrel red-backed vole heather vole	high

MP - MOLAR PASS ECOSECTION

The Molar Pass (MP) Ecosection encompasses morainal landforms of calcareous, medium textured till in the Alpine Ecoregion. It is dominated by Brunisolic and Regosolic soils under mountain avens and heath tundra. Table 77 summarizes the MP1 Ecosite and Fig. 25 indicates the landscape position.

Table 77. General features of the MP1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
MP1	Blanket, veneer over inclined, hummocky, & ridged bedrock	Till C (calcareous, medium textured)	Eutric & Melanic Brunisol, Regosol, Humic Regosol	Mountain avens tundra (H1), heath tundra (L5).

MP1 occurs on valley walls, valley shoulders, cirque basins and cols. Veneers of Eolian material B (altered, medium textured) are most extensive on MP1 tracts of western Banff and southwestern Jasper. Slopes range from 5 to 45%. Soils are well to moderately well drained. Lithic and turbic soil phases occur. Solifluction and cryoturbation are common surface modifiers. Mountain avens tundra (H1) is abundant on most tracts.

Table 78. Wildlife features of the MP1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
MP1	medium	bighorn sheep mountain goat	low	wolverine	low	pika hoary marmot columbian ground squirrel golden-mantled ground squirrel	low

MP1 is of low importance to most wildlife. It is highly important to sheep, goat and some small mammals, especially in summer.

MANAGEMENT CONSIDERATIONS

An intricate pattern of soils and vegetation, related to geomorphic activity, necessitates detailed evaluation of individual tracts for trails, campgrounds, and related park uses. Of particular concern are soliflucted and cryoturbated localities and sites with imperfect drainage. Vegetation is expected to recover slowly from disturbances.

MQ - MOSQUITO ECOSECTION

The Mosquito (MQ) Ecosection encompasses fluvial fan and apron landforms dominated by Brunisolic and Regosolic soils and Engelmann spruce–subalpine fir open and closed forests in the Upper Subalpine portion of the Subalpine Ecoregion. It occurs on lower slopes and valley floors. Table 79 outlines features of the MQ1 Ecosite.

Table 79. General features of the MQ1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
MQ1	Fan, apron	Fluvial material B (calcareous, coarse-stratified)	Eutric Brunisol, Regosol	Engelmann spruce - subalpine fir closed and open forest (C15, O10)

Fluvial material A (noncalcareous, coarse stratified) occurs on some tracts. Veneers of Eolian material B (altered, medium textured) occur occasionally. Slopes range from 5 to

45% and are often channeled. Soils are well to moderately well drained.

WILDLIFE

Table 80. Wildlife features of the MQ1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
MQ1	high	deer moose elk	very high	wolf marten wolverine coyote cougar	medium	snowshoe hare columbian ground squirrel red squirrel	high

MQ1 is highly important to wildlife. The alluvial landforms are vegetated with a well developed shrub layer beneath the spruce-fir forest canopy which is forage for ungulates and cover for breeding birds. Deep snow limits large mammal activity in winter.

MANAGEMENT CONSIDERATIONS

Gently sloping MQ1 tracts dominated by Brunisolic soils generally have no limits for campgrounds, trails, or related park uses. However, Regosolic soils dominate some tracts where fluvial deposition is sufficiently frequent to maintain these weakly developed soils. This is the major factor in planning of certain park uses. Locally occurring coarse textures and high water tables present problems for sewage disposal. The coarse textured material provides gravel for construction purposes. The high content of coarse fragments may cause problems for some uses, e.g. trails, campgrounds, or playgrounds. Several tracts are locally avalanched, a factor to be considered for some uses.

EACH TRACT SHOULD BE EVALUATED IN DETAIL FOR SPECIFIC PROPOSED USES.

NG - NIGEL ECOSECTION

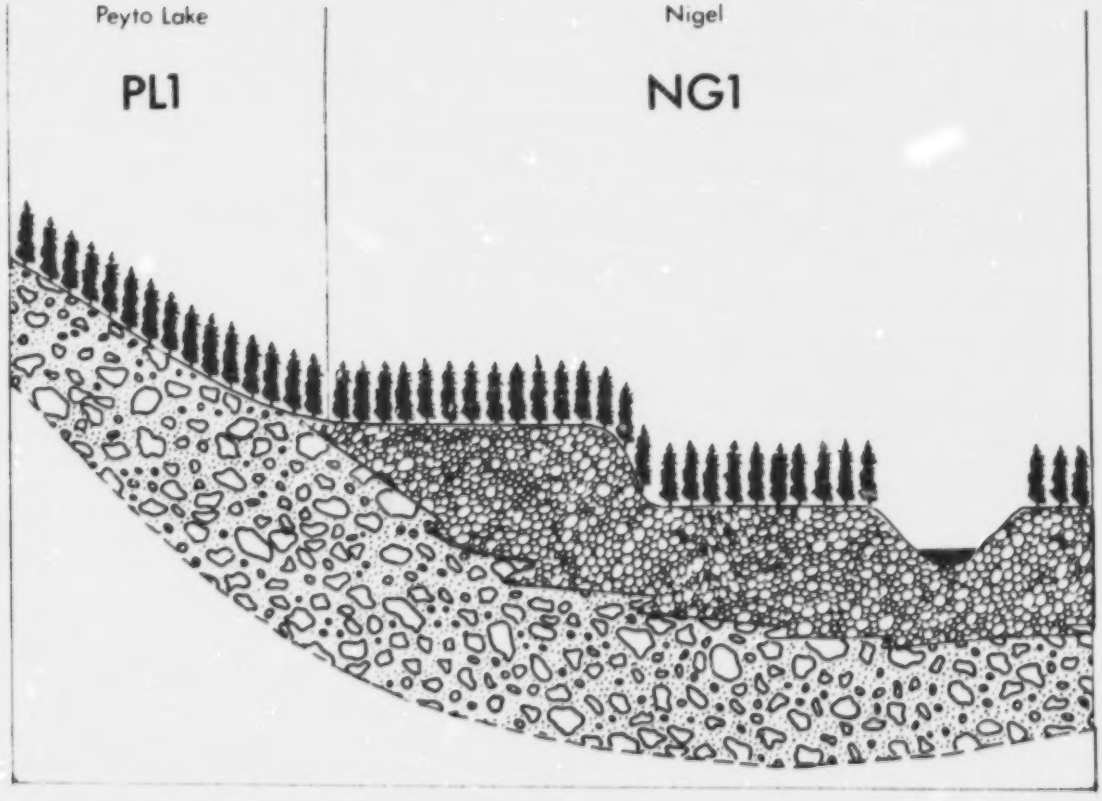
The Nigel (NG) Ecosection encompasses terraced landforms of calcareous glaciofluvial material in the Upper Subalpine portion of the Subalpine Ecoregion. It is dominated by soils under Engelmann spruce-subalpine fir closed and open forest. Table 81 outlines the features of the NG1 Ecosite. Landscape position is shown in Fig. 22.

Only two NG1 tracts were mapped, both in Banff. Thin veneers of Eolian material B (altered, medium textured) occur. Soils are well drained. NG1 occurs on valley floors. Slopes range from 1 to 15%.

Table 81. General features of the NG1 Ecosite.

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
NG1	Terraced	Glaciofluvial material B (calcareous, coarse textured)	Eutric Brunisol	Engelmann spruce - subalpine fir closed and open forest (C15, O10)

Fig. 22 Landscape schematic of the Nigel 1 (NG1) Ecosite.



WILDLIFE

NG1 is of low importance to wildlife except birds.

Table 82. Wildlife features of the NG1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
NG1	low		low		low		high

MANAGEMENT CONSIDERATIONS

NG1 is of very limited areal extent. Level topography and valley floor positions are conducive to many uses. Coarse textures provide gravel supplies. Coarse textured material is ineffective as an ion filter, a factor to be considered in sewage disposal system design. The coarse textures also promote droughtiness and problems in revegetation are likely to occur. The high content of coarse fragments may affect some uses, e.g. trails or campgrounds.

NH - NASHAN ECOSECTION

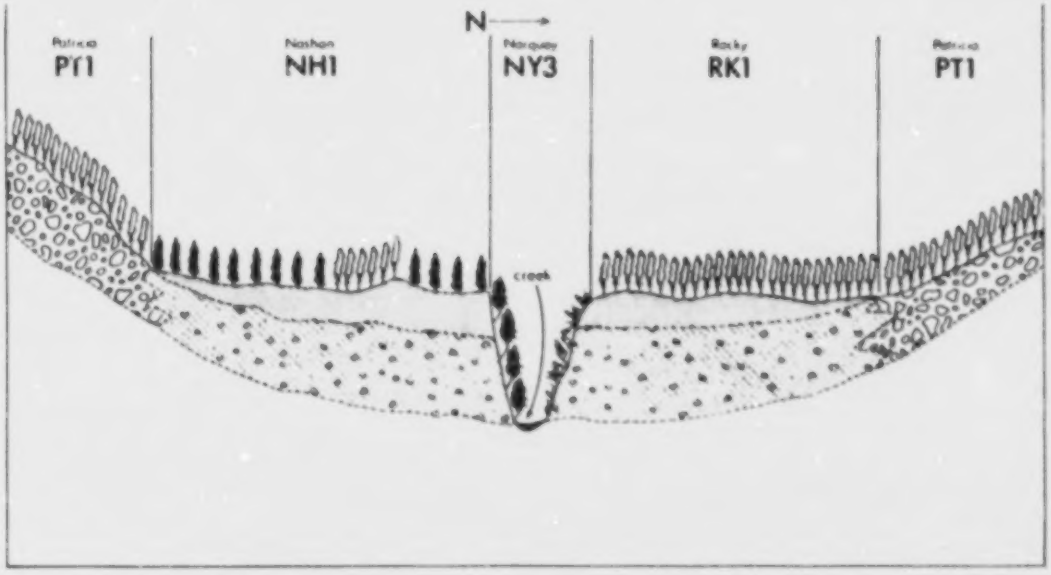
The Nashan (NH) Ecosection encompasses a wet > dry landscape pattern on glaciolacustrine landforms in the Montane Ecoregion. Wet (poorly drained) segments are dominated by Gleysolic soils under spruce open forest. Dry (well to moderately well drained) segments are dominated by Luvisolic and Brunisolic soils under lodgepole pine forest. Table 83 outlines the features of the NH1 Ecosite. Landscape position is shown in Fig. 23.

Table 83. General features of the NH1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
NH1	Glaciolacustrine blanket over undulating & hummocky glacial materials	Glaciolacustrine material (calcareous, fine textured)	Wet 80: Gleysol Dry 20: Gray Luvisol > Brunisol	Spruce open forest (O11) Lodgepole pine forest (C19, C29)

The glaciolacustrine material overlies Ice Contact Stratified Drift B (calcareous, variably textured). Wet segments usually have thin organic veneers of fen peat and veneers of Fluviolacustrine material A (altered, fine stratified). Dry segments have thin, discontinuous veneers of Eolian material B (altered, medium textured). Complex slopes range from 0 to 10%. NH1 occurs only in Jasper.

Fig 23 Landscape schematic of the Nashan 1 (NH1) Ecosite in relation to other Ecosites.



WILDLIFE

Table 84. Wildlife features of the NH1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
NH1	low	moose	medium	lynx	medium	pika red squirrel	medium

NH1 is moderately important to wildlife. Moose forage here extensively. Boreal species such as white-throated sparrow and spring peeper occur on this Ecosite of

limited area.

MANAGEMENT CONSIDERATIONS

Poor drainage, resulting from surface water collection on slowly pervious, fine textured, glaciolacustrine material, severely limits many park uses unless expensive construction techniques are followed.

NT - NUM-TI-JAH ECOSECTION

The Num-Ti-Jah (NT) Ecosection encompasses wet fluvial and fluviolacustrine landforms on col and valley floors in the Upper Subalpine portion of the Subalpine Ecoregion. Gleysolic soils characterize NT but Organic soils are also common on the NT3 Ecosite. The NT2 Ecosite has wet herb and moist shrub thicket vegetation, whereas NT3 has wet herb meadow, cottongrass fen, and sedge fen. Table 85 shows the landform, soil, and vegetational differences of the NT Ecosites. Landscape positions are shown in Figs. 20, 30 and 31.

Table 85. General features of the NT Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
NT2	Level, apron, fan	Fluvial materials A & B (noncalcareous & calcareous, coarse-stratified)	Gleysol	Wet shrub thicket (S8), moist shrub thicket (S4, S11)
NT3	Level, horizontal fen	Fluviolacustrine materials A & B (altered & calcareous, fine-stratified), fen peat	Gleysol, Mesisol	Wet herb meadow (H9), cottongrass fen (H10), sedge fen (H11)

Wetness on NT results from high water tables, seepage, and discharge, resulting in imperfectly to very poorly drained soils. Important accessory deposits include fluviolacustrine materials and fen peat for NT2, fluvial materials for NT3. Soils in active or recently active sedimentation environments lack surface peat layers, whereas soils of geomorphically inactive localities have surface organic layers and include Mesisols on horizontal fens in ponded localities. Although most NT3 tracts are ponded, recent geomorphic conditions favor organic material accumulation. Slopes are often channeled and range from 0 to 15% on NT2, 0 to 3% on NT3.

WILDLIFE

NT is moderately important to wildlife. High densities of small mammals occur on NT3. The Ecosection is used by all species of ungulates but is highly important to deer and moose. Critical winter habitat for white-tailed ptarmigan occurs where there are willow meadows.

Table 86. Wildlife features of the NT Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
NT2	low	deer moose	medium	coyote wolf	low	meadow vole columbian ground squirrel	low
NT3	low	deer moose	low	coyote wolf	high	meadow vole western jumping mouse	medium

MANAGEMENT CONSIDERATIONS

Imperfect to very poor drainage, resulting from high water tables and backwater flooding, severely limits most park uses unless expensive construction techniques are followed. On some NT tracts, sedimentation accompanies flooding. NT3 is of limited areal extent. Vegetation on NT3 is easily damaged and slow to recover from disturbances.

EACH TRACT SHOULD BE EVALUATED IN DETAIL FOR SPECIFIC PROPOSED USES.

NY - NORQUAY ECOSECTION

The Norquay (NY) Ecosection encompasses calcareous glacial landforms dominated by Brunisolic and Regosolic soils in the Montane Ecoregion. Vegetation includes lodgepole pine forest, Douglas fir open and closed forest, white spruce-Douglas fir forest, and low shrub-herb meadow. Two NY Ecosites are separaterd by genetic material differences and distribution patterns of soils and vegetation (Table 87). Landscape position is shown in Fig. 24.

NY1 occurs on lower valley walls; the linear surface form is considered depositional. Till B (noncalcareous, medium textured) dominates NY1 tracts mapped in the Miette River valley. Slopes range from 30 to 70% and are frequently gullied. Soil and vegetation patterns reflect surface erosional processes and moisture regime. Soils are rapidly to well drained.

NY3 occupies valley floor including benchland positions, usually adjacent to streams. Inclined surfaces are erosional (i.e. river banks), hummocky surfaces are depositional. Slopes range from 15 to 70% and are usually gullied. The pattern of soils and vegetation is governed by aspect, exposure, and erosional processes giving distinct northerly (well drained) versus southerly (rapidly drained) aspects.

WILDLIFE

NY is very important to wildlife. Critical range for deer, sheep and elk occurs on the open slopes. High densities of small mammals occur on dry areas. Associated with the concentrations of ungulates and small mammals are relatively high numbers of carnivores.

Table 87. General features of the NY Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
NY1	Blanket, veneer over inclined bedrock	Till C (calcareous, medium textured)	Eutric Brunisol > Regosol	Lodgepole pine forest (C6), Douglas fir forest (C1)
NY3	Inclined, hummocky	Ice contact stratified Drift B (calcareous, variably textured)	Northerly: Eutric Brunisol Southerly: Regosol	White spruce - Douglas fir forest (C5), lodgepole pine forest (C19). Douglas fir open and closed forest (O5, C1), low shrub-herb meadow (L1)

Fig. 24 Landscape schematic of the Norquay (NY) Ecosites in relation to other Ecosites.

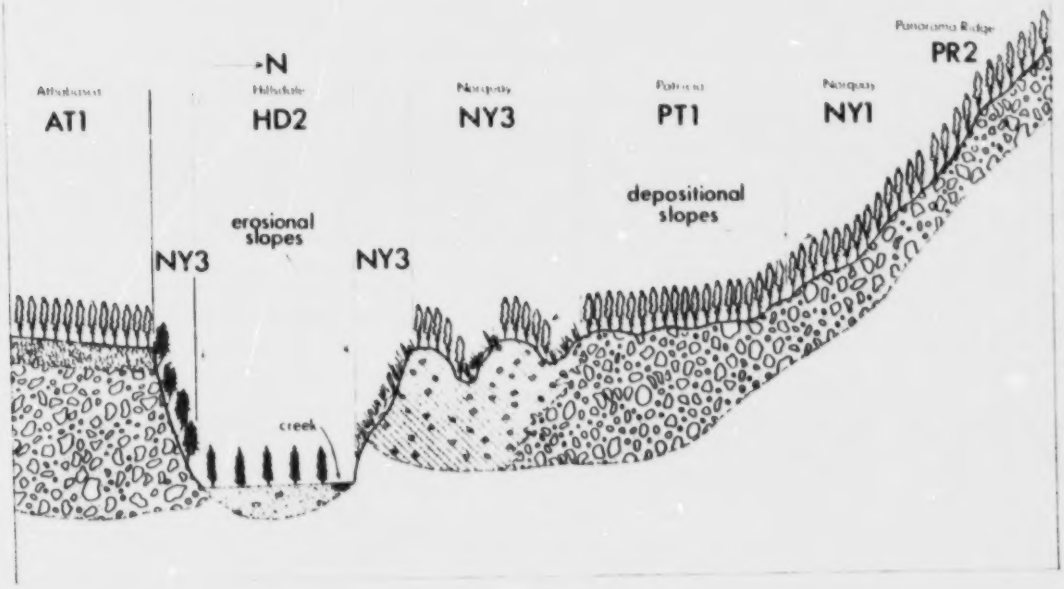


Table 88. Wildlife features of the NY Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
NY1	very high	deer bighorn sheep elk	high	wolf coyote cougar	high	columbian ground squirrel	medium
NY3	very high	deer elk bighorn sheep	very high	wolf coyote cougar marten	very high	red squirrel deer mouse heather vole long-tailed vole	high

MANAGEMENT CONSIDERATIONS

Steep and locally eroding slopes are limiting factors to be considered for most park uses on NY1 and NY3. Of particular concern on NY3 are the dry, southerly aspects where vegetation removal would increase erosion. Further, the subxeric vegetation of the southerly aspect segment is expected to recover slowly from disturbance. Coarse fragments may impose limitations to use of some slopes.

PL - PEYTO LAKE ECOSECTION

The Peyto Lake (PL) Ecosection encompasses calcareous morainal landforms dominated by Eutric Brunisols and coniferous forest in the Upper Subalpine portion of the Subalpine Ecoregion. Engelmann spruce-subalpine fir closed and open forest, subalpine larch-subalpine fir forest, a distinctive pattern of tundra plus coniferous open forest, and a dry > wet landscape pattern differentiate the four PL Ecosites as outlined in Table 89. Landscape positions are shown in Fig. 25.

PL occurs on valley walls, floors, and shoulders, and in cirque basins and cols. Slopes range from 5 to 70% and are often gullied on PL1. Veneers of Eolian material B (altered, medium textured) occur extensively in western Banff and southwestern Jasper, sporadically elsewhere. Podzolic soils are associated with the eolian veneers. Soils of PL1, PL3, PL4, and dry segments of PL5 are well to moderately well drained and imperfectly to poorly drained on wet segments of PL5. subalpine larch-subalpine fir/grouseberry-everlasting forest occurs only in southern Banff. Lithic soil phases are important on PL4 and PL5, turbic soil phases on PL4. Depressional segments of some PL5 tracts consist of Fluvial material B (calcareous, coarse-stratified).

WILDLIFE

PL is moderately important to wildlife. Large mammals rarely occur here in winter because of the deep snow. In contrast, some hibernating small mammals are very common.

Table 89. General features of the PL Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
PL1	Blanket over inclined bedrock	Till C (calcareous, medium textured)	Eutric Brunisol	Engelmann spruce - subalpine fir closed and open forest (C15, C21, O10)
PL3	Blanket over inclined, hummocky & ridged bedrock	Till C (calcareous, medium textured)	Eutric Brunisol > Humo-Ferric Podzol	Subalpine larch - subalpine fir forest (C23)
PL4	Blanket, veneer over inclined, hummocky & ridged bedrock	Till C (calcareous medium textured)	Eutric Brunisol > Melanic Brunisol, Ferro-Humic Podzol	Heath tundra (L5) > Engelmann spruce-subalpine fir open forest (O10)
PL5	Blanket, veneer over hummocky & ridged bedrock	Till C (calcareous medium textured)	Dry 70: Eutric Brunisol Wet 30: Gleysol, gleyed Podzolic & Brunisolic	Engelmann spruce - subalpine fir closed and open forest (C15, O10), subalpine larch-subalpine fir forest (C23) Wet shrub thicket (S8, S11)

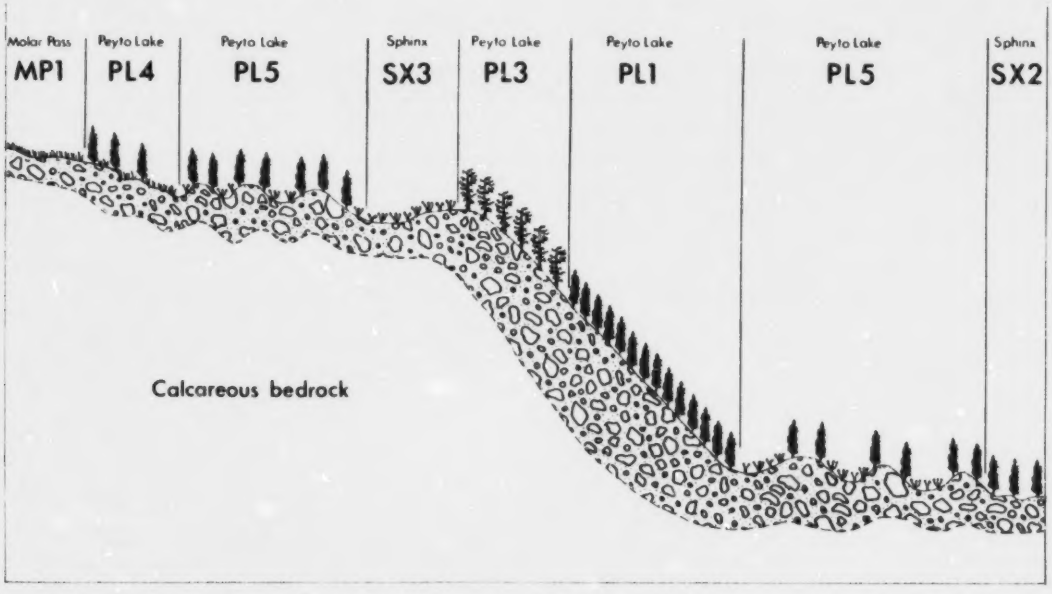
MANAGEMENT CONSIDERATIONS

The PL Ecosites can be treated as having similar responses to management, except for PL3 because of its limited areal extent and the wet segments of PL5 which necessitate special considerations for some uses (e.g. trail construction). Steepness of slope is the major factor to consider in planning of park uses. The eolian veneers, common in some areas, tend to erode easily where vegetation is removed. Locally occurring avalanche paths and occasional seeps will affect certain uses. Heath tundra vegetation on PL4 is slow to recover from disturbances.

PP - PIPESTONE ECOSECTION

The Pipestone (PP) Ecosection encompasses calcareous fluvial apron and fan landforms dominated by Regosolic soils in the Lower Subalpine portion of the Subalpine Ecoregion. Vegetation includes lodgepole pine forest, poplar forest, Engelmann spruce-subalpine fir open and closed forest, white spruce open forest, shrub thicket, shrubby meadow, and herb mat. Table 91 outlines six PP Ecosites separated primarily

Fig. 25 Landscape schematic of the Peyto Lake (PL) Ecosite in relation to other Ecosites.



on vegetational differences.

PP occurs on lower slopes and along streams on valley floors; channeling is a common surface feature. Slopes range from 2 to 45%; soils are rapidly to moderately well drained. Landforms are geomorphologically active and are subject to episodic flooding. PP2 is of limited areal extent and mapped only in Jasper. The majority of PP4 tracts occur close to the Continental Divide and are always found in close proximity to large glaciers or icefields. PP6 and PP7 tracts occur primarily in the Front Ranges.

WILDLIFE

The importance of this Ecosection to wildlife varies with each Ecosite. PP1, PP2, PP3 and PP4 are moderately important, while PP6 and PP7 are highly important. PP6 and PP7 have a well developed shrub and herb layer which increases their importance as foraging areas for ungulates and small mammals. Snow depths up to 1 m restrict ungulate use in winter.

MANAGEMENT CONSIDERATIONS

Management considerations are very similar for PP1, PP2, PP3, PP6 and PP7. Fluvial deposition is sufficiently frequent to maintain the Regosolic soils and is the major factor to consider when planning park uses. Locally occurring coarse textures and high

Table 90. Wildlife features of the PL Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
PL1	medium	caribou	high	marten weasel	low	pika columbian ground squirrel golden-mantled ground squirrel	low
PL3	low	deer	low	wolverine	high	least chipmunk heather vole meadow vole	low
PL4	medium	mountain goat bighorn sheep	medium	weasel wolverine cougar	medium	least chipmunk hoary marmot columbian ground squirrel red-backed vole	medium
PL5	medium	elk	medium	wolf coyote	medium	pika columbian ground squirrel heather vole	low

water tables present problems for sewage disposal, however coarse textured material provides gravel for construction purposes. PP2 is of limited areal extent. PP4 is somewhat different in that its level topography and valley floor positions are conducive to many uses. The active glaciofluvial environment of PP4 is subject to local flooding, high water tables, and shifting stream channels. The coarse textures require the same considerations as for the other PP Ecosites. Vegetation on PP4 can probably withstand moderate use but once destroyed is expected to recover slowly. Major construction activities (e.g. roads) will change sedimentation and erosion patterns on PP4.

EACH PP TRACT SHOULD BE EVALUATED IN DETAIL FOR SPECIFIC PROPOSED USES.

PR - PANORAMA RIDGE ECOSECTION

The Panorama Ridge (PR) Ecosection encompasses calcareous glacial landforms dominated by a Brunisolic > Luvisolic soil complex and lodgepole pine forest within the Lower Subalpine portion of the Subalpine Ecoregion. Genetic material differences, episodic seepage, a northerly-southerly aspect landscape pattern, and vegetational differences separate the five PR Ecosites (Table 93). Landscape positions are shown in Fig. 26.

PR occurs on valley walls and floors including benchlands. Veneers of Eolian material B (altered, medium textured) occur locally especially in western Banff and southwestern Jasper. Slopes range from 15 to 70% and are often gullied except on PR3 where failed slopes are common. Soils of PR1, PR2, and PR6 are well drained; soils of PR3 are imperfectly drained and are affected by eposodic, near-surface seepage. PR4 landforms are erosional and the pattern of soils and vegetation is governed by northerly (well to moderately well drained) versus southerly (rapidly to well drained) aspects.

Table 91. General features of the PP Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
PP1	Fan, apron	Fluvial material B (calcareous, coarse -stratified)	Regosol	Lodgepole pine forest (C19, C3, C6)
PP2	Fan, apron	Fluvial material B (calcareous, coarse -stratified)	Regosol	Poplar forest (C16, C17)
PP3	Fan, apron	Fluvial material B (calcareous, coarse -stratified)	Regosol	Engelmann spruce-subalpine fir forest (C13, C31)
PP4	Fan, level	Glaciofluvial material B (calcareous, coarse textured)	Regosol	Herb mat (H8)
PP6	Fan, apron	Fluvial material B (calcareous, coarse -stratified)	Regosol	Engelmann spruce-subalpine fir open forest (O18), white spruce open forest (O17).
PP7	Fan, apron	Fluvial material B (calcareous, coarse-stratified)	Humic Regosol, Regosol	Shrubby meadow (S9), shrub thicket (S10)

WILDLIFE

PR is moderately important to wildlife. For some carnivores and many small mammals, most Ecosites are highly or very important. There is little forage to attract ungulates to this Ecosection and deep snow restricts most large mammal presence in winter.

MANAGEMENT CONSIDERATIONS

The PR1, PR2, and PR4 Ecosites have management concerns that are similar. Steepness of slope is the major factor to consider in planning of park uses. Locally occurring avalanche paths and seeps on PR1 and PR2, and locally eroding slopes on PR4 will affect certain uses.

Episodic, subsurface lateral water flow is the salient characteristic to be considered in planning park uses of PR3. The land surface is relatively dry, except for seeps, and presents no limits to low intensity uses on undisturbed surfaces. However, removal of surface and subsurface material may create seepage-induced slope failure. Slope failure is a common feature of PR3 and could be a continuing problem in some areas, e.g. a PR3/7c tract at Village Lake Louise in Banff that was investigated by TES Research and Consulting Ltd. (1973).

Table 92. Wildlife features of the PP Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
PP1	medium	elk	high	wolf coyote lynx cougar	medium	snowshoe hare columbian ground squirrel golden-mantled ground squirrel red squirrel red-backed vole	medium
PP2	medium	elk deer	very high	wolf weasel cougar	medium	dusky shrew red squirrel deer mouse meadow vole	medium
PP3	medium	moose	high	lynx	high	snowshoe hare golden-mantled ground squirrel deer mice porcupine	medium
PP4	medium	moose	medium		medium		low
PP6	high	moose elk	very high	wolf coyote weasel lynx cougar	high	snowshoe hare least chipmunk deer mouse	low
PP7	very high	moose elk	high	wolf cougar	low	columbian ground squirrel	low

PR6 has no characteristics limiting for campgrounds, trails, or related uses. Locally occurring coarse textured materials provide gravel sources but may present problems in sewage disposal due to ineffective ion filtration.

PT - PATRICIA ECOSECTION

The Patricia (PT) Ecosection encompasses calcareous glacial landforms dominated by Brunisolic and Luvisolic soils in the Montane Ecoregion. Vegetation is dominated by lodgepole pine and aspen forests. Four PT Ecosites are differentiated by vegetation, lithic soil phases, and a dry > wet landscape pattern (Table 95). Landscape positions are shown in Figs. 27 and 24.

PT occurs on valley floor benchlands; Ice Contact Stratified Drift B (calcareous, variably textured) is a significant constituent of some tracts. Veneers of Eolian material A (calcareous, medium textured) and Eolian material B (altered, medium textured) occur sporadically. Soils of PT1, PT3, PT4 and dry segments of PT5 are rapidly to well drained; poorly to very drained on wet segments of PT5. Bedrock outcrops are common on PT3. Slopes range from 2 to 70% and are usually complex.

Table 93. General features of the PR Ecosites.

Ecosite	Surface Expression	Genetic Material Unit	Soil	Vegetation
PR1	Blanket over inclined bedrock	Till C (calcareous, medium textured)	Eutric Brunisol > Gray Luvisol	Lodgepole pine forest (C11,C20, C29)
PR2	Blanket over inclined bedrock	Till C (calcareous, medium textured)	Eutric Brunisol > Gray Luvisol	Lodgepole pine/ buffaloberry (C6, C18, C19)
PR3	Blanket over inclined & hummocky bedrock, hummocky	Till C (calcareous, medium textured)	Gleyed Eutric Brunisol > gleyed Gray Luvisol	Lodgepole pine/ buffaloberry (C18, C19)
PR4	Inclined	Till C (calcareous, medium textured) and Ice contact stratified Drift B (calcareous, variably textured)	Northerly: Eutric Brunisol Southerly: Eutric Brunisol > Gray Luvisol, Regosol	Engelmann spruce - subalpine fir forest (C13, C14) Lodgepole pine forest (C3, C6, C19)
PR6	Blanket over inclined & hummocky bedrock, hummocky	Ice contact stratified Drift B (calcareous, variably textured)	Eutric Brunisol > Gray Luvisol	Lodgepole pine forest (C11, C18, C19, C29)

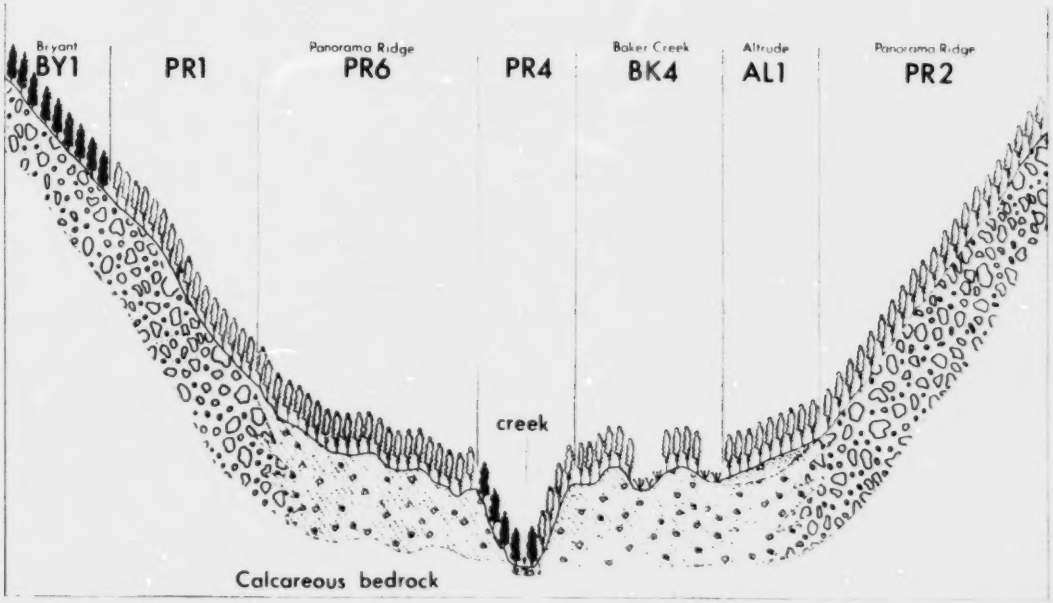
WILDLIFE

PT is highly important to wildlife. Located in the warmer Montane zone with low snow acumulation, it is winter range for elk and deer. Some small mammals, especially red squirrels, occur here in large numbers while carnivores also concentrate here. Breeding bird densities are high to very high.

MANAGEMENT CONSIDERATIONS

The PT Ecosites can all be treated similarly regarding management concerns, except for PT4 because of its limited areal extent. Also, the wet segments of PT5 necessitate special considerations for some uses (e.g. trail construction). Tracts with gentle slopes generally have no characteristics limiting for park uses. Moderate to steep, irregular slopes with shallow soils and bedrock outcrops are major factors in planning park uses, especially on PT3 where colluviation is common on exceptionally steep south facing slopes. The textural variability of ice contact stratified drift, common on some valley floor tracts, may influence some uses.

Fig. 26 Landscape schematic of the Panorama Ridge (PR) Ecosite in relation to other Ecosites.



RD - REDOUBT ECOSECTION

The Redoubt (RD) Ecosection (Table 97) encompasses inclined, noncalcareous, medium textured colluvium in the Alpine Ecoregion. Soils are Dystric and Sombric Brunisols, Regosolics, and Humic Regosols. Vegetation is characterized by mountain avens tundra and heath tundra. Landscape position is shown in Figs. 20 and 31.

RD1 occurs on steep, usually linear slopes in areas that are geologically dominated by Miette Group in the Main Ranges or noncalcareous Mesozoic strata in the Front Ranges. Colluvial processes are locally active and include avalanching, soil creep, cryoturbation and solifluction. Slopes range from 45 to 70%. Soils are well drained. Unvegetated portions may constitute up to 50% of RD1 tracts.

WILDLIFE

RD1 is moderately important to wildlife but highly important for sheep, goats and some small mammals. In winter these areas are frequently blown free of snow allowing ungulates to graze easily.

Table 94. Wildlife features of the PR Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
PR1	low	deer	high	wolf wolverine	low	columbian ground squirrel golden-mantled ground squirrel	high
PR2	medium	elk	very high	marten weasel lynx wolf coyote cougar	medium	snowshoe hare columbian ground squirrel golden-mantled ground squirrel red squirrel red-backed vole	low
PR3	medium	moose	medium		high	red-backed vole long-tailed vole	medium
PR4	medium		high	coyote marten wolverine	very high	golden-mantled ground squirrel red squirrel deer mouse red-backed vole long-tailed vole western jumping mouse	medium
PR6	medium	deer	high	marten lynx wolf coyote cougar	medium	snowshoe hare porcupine	medium

MANAGEMENT CONSIDERATIONS

Steep and locally unstable (colluviating) slopes are limiting factors for many park uses. Slope failure is a feature of some RD1 tracts. Potential for slope failure is unknown. Removal of vegetation will result in wind, water, and gravity erosion. Vegetation is expected to recover slowly from disturbances.

RK - ROCKY ECOSECTION

The Rocky (RK) Ecosection encompasses glaciolacustrine landforms dominated by Luvisolic and Brunisolic soils and lodgepole pine forest in the Montane Ecoregion (Table 99). Landscape position is shown in Fig. 23.

RK1 is mapped only in Jasper and occurs on valley floor benchlands. The glaciolacustrine material overlies Ice Contact Stratified Drift B (calcareous, variable textured). Surficial veneers of Eolian material B (altered, medium textured) occur on some tracts. Slopes range from 2 to 10%. Soils are well to moderately well drained.

WILDLIFE

Table 95. General features of the PT Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
PT1	Ridged & hummocky including bedrock control (blanket)	Till C (calcareous, medium textured)	Eutric Brunisol, Gray Luvisol	Lodgepole pine forest (C6,C19)
PT3	Veneer over ridged bedrock - ridged bedrock	Till C (calcareous, medium textured	Eutric Brunisol - Gray Luvisol (lithic phases)	Lodgepole pine forest (C3, C6, C19)
PT4	Ridged including bedrock control (blanket)	Till C (calcareous, medium textured)	Eutric Brunisol, Gray Luvisol	Aspen forest (C16)
PT5	Ridged - horizontal fen	Till C (calcareous, medium textured) - fen peat	Dry 60: Eutric Brunisol, Gray Luvisol Wet 40: Glevsol Mesisol	Lodgepole pine forest (C6, C11, C19) Black spruce-lodgepole pine forest (C8), spruce open forest

Table 96. Wildlife features of the PT Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
PT1	high	deer elk	high	coyote cougar wolf	high	red squirrel red-backed vole	high
PT3	high	deer moose elk	high	cougar wolf coyote	high	red squirrel deer mouse big brown bat	high
PT4	medium	deer bighorn sheep elk	high	wolf coyote cougar	high	red squirrel meadow vole	very high
PT5	medium	deer	high	coyote cougar lynx wolf	medium	snowshoe hare red squirrel meadow vole	high

RK 1 is moderately important to wildlife overall but very important to small mammals.

MANAGEMENT CONSIDERATIONS

Although considered to be dry (well to moderately well drained), the slow infiltration and permeability rates of the fine textured glaciolacustrine material will create problems where water can collect (e.g. depressions on trails). Removal of vegetation will significantly increase the chances for water and wind erosion, including slumps.

Fig. 27 Landscape schematic of the Patricia (PT) Ecosites in relation to other Ecosites.

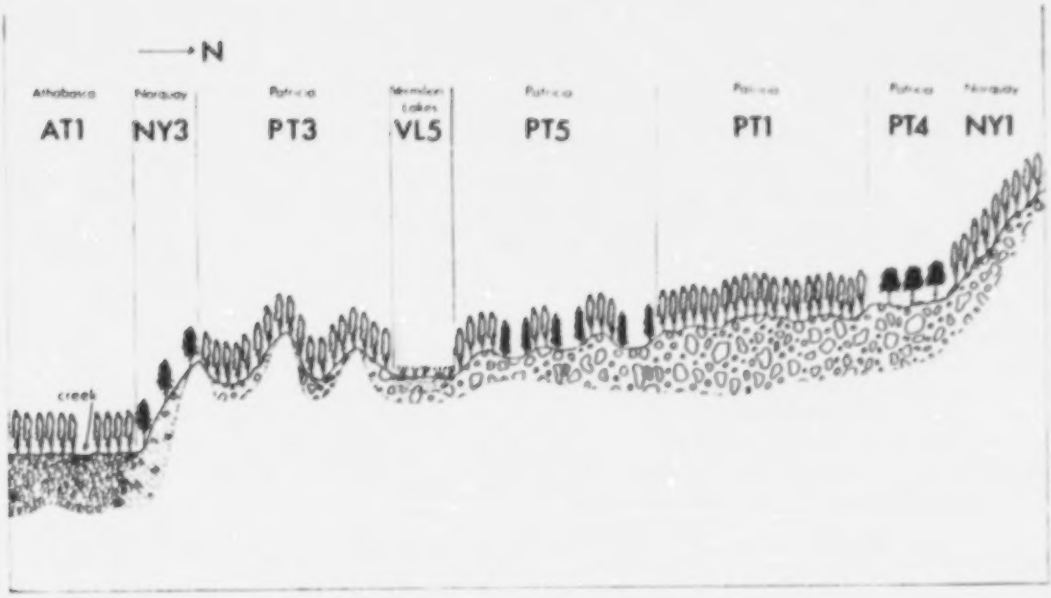


Table 97. General features of the RD1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
RD1	Blanket & veneer over inclined bedrock	Colluvium B (non-calcareous, medium textured)	Dystric & Sombric Brunisol, Regosol, Humic Regosol	Mountain avens tundra (H1), heath tundra (L5)

Table 98. Wildlife features of the RD1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
RD1	high	bighorn sheep mountain goat	low		medium	pika hoary marmot columbian ground squirrel golden-mantled ground squirrel	low

Table 99. General features of the RK1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soil	Vegetation
RK1	Glaciolacustrine blanket over undulating & hummocky glacial materials	Glaciolacustrine material (calcareous, fine textured)	Gray Luvisol > Eutric Brunisol	Lodgepole pine forest (C19, C29)

SB - SAWBACK ECOSECTION

The Sawback (SB) Ecosection encompasses inclined landforms of calcareous, medium textured colluvium in the Lower Subalpine portion of the Subalpine Ecoregion. Brunisolic and Regosolic soils dominate under avalanche complex v.t.s., Engelmann spruce-subalpine fir forest, lodgepole pine forest, coniferous open forest, shrub-herb meadow, and grassland. The five SB Ecosites are separated primarily by vegetational features (Table 101). Landscape positions are shown in Figs. 28 and 29.

SB occurs on or below steep valley walls and is associated with calcareous bedrock. Slopes generally range from 45 to 100% and snow avalanching characteristically affects more than 50% SB1. Soils are rapidly to moderately well drained. Unvegetated portions constitute up to 50% of some SB1 and SB4 tracts. SB5 occurs primarily in the Front Ranges on dry, southerly aspects. SB4 is the steepest of the five SB Ecosites and has the greatest abundance of lithic soils and bedrock outcrops. Avalanche Compex 1, for SB1, is a heterogeneous complex of v.t.s. that includes subalpine fir-willow (S2), willow-dwarf birch-shubby cinquefoil (S10), hairy wild rye-wild strawberry-fireweed (H5), aspen/hairy wild rye-showy aster (C22), plus intergrades, with S2 and H5 being most abundant.

Table 100. Wildlife features of the RK1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
RK1	low	elk	medium	lynx cougar	very high	masked shrew snowshoe hare least chipmunk red squirrel deer mouse	medium

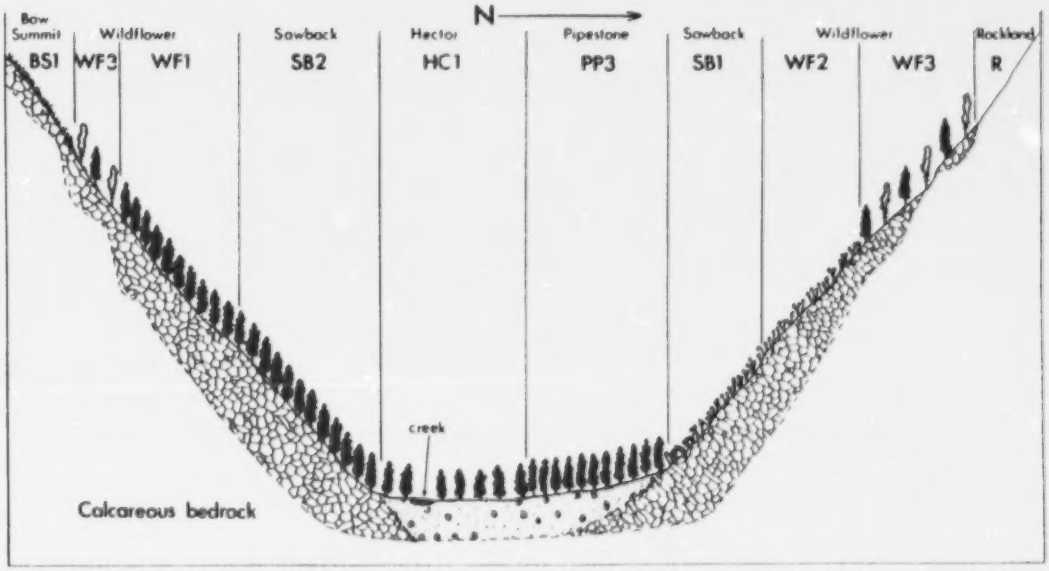
Table 101. General features of the SB Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
SB1	Blanket over inclined bedrock, apron	Colluvium C (calcareous, medium textured	Eutric Brunisol, Regosol, Humic Regosol	Avalanche Complex 1 > Engelmann spruce - subalpine fir forest (C13, C14)
SB2	Blanket over inclined bedrock, apron	Colluvium C (calcareous, medium textured	Eutric Brunisol, Regosol	Engelmann spruce - subalpine fir forest (C13, C14)
SB3	Blanket over inclined bedrock, apron	Colluvium C (calcareous, medium textured)	Eutric Brunisol, Regosol	Lodgepole pine forest (C3, C6, C19)
SB4	Blanket, veneer over inclined bedrock > inclined bedrock	Colluvium C (calcareous, medium textured)	Eutric Brunisol, Regosol, Humic Regosol	Coniferous open forest (O4, O17) > lodgepole pine forest (C3), shrub-herb meadow (L1)
SB5	Blanket, veneer over inclined bedrock	Colluvium C (calcareous, medium textured)	Eutric & Melanic Brunisol, Humic Regosol	Grassland (H14)

Table 102. Wildlife features of the SB Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
SB1	high	mountain goat bighorn sheep	medium		high	masked shrew pika least chipmunk deer mouse long-tailed vole western jumping mouse	high
SB2	medium		low		medium	western jumping mouse	medium
SB3	medium	moose bighorn sheep	high	marten wolverine coyote	high	snowshoe hare yellow pine chipmunk	low
SB4	medium	mountain goat bighorn sheep	low	cougar	medium	pika least chipmunk	medium
SB5	very high	bighorn sheep deer elk mountain goat	medium	cougar wolf coyote	medium	deer mouse	low

Fig. 28 Landscape schematic of the Sawback Ecosites in relation to other Ecosites.



SB is highly important for wildlife. Critical winter range for sheep and goats occurs here as well as high densities of some small mammals, birds and carnivores. Located in the Front Ranges, SB Ecosites do not receive much snow and consequently ungulates can easily crater for forage, especially on SB5.

MANAGEMENT CONSIDERATIONS

Steep and locally unstable (colluviating) slopes are limiting factors to be considered for many park uses. Snow avalanching, whether local (on SB2, SB3, SB4) or extensive (SB1), will affect winter uses. Shallow soils and bedrock outcrops on SB4 are factors to be considered when planning certain uses (e.g. trails). It is expected that vegetation on SB4 and SB5 recovers slowly from disturbances and that vegetation removal on SB5 will significantly increase erosion, particularly colluviation. Droughty conditions on SB5 will compound potential revegetation problems.

SF - SNOWFLAKE ECOSECTION

The Snowflake (SF) Ecosection (Table 103) encompasses morainal landforms dominated by Cryosolic soils and Engelmann spruce–subalpine fir forest in the Upper Subalpine portion of the Subalpine Ecoregion. The SF Ecosection develops on northerly aspects in the Front Ranges of both Banff and Jasper, from Banff townsite northwestward. Landscape position is shown in Fig. 29.

Table 103. General features of the SF1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
SF1	Blanket over inclined bedrock	Till B & C (noncalcareous & calcareous, medium textured)	Static Cryosol >Gleyed Eutric Brunisol	Engelmann spruce - subalpine fir forest (C13, C24)

SF1 occurs on valley wall slopes and is associated with materials derived from Mesozoic strata. Failed and soliflucted slopes are common; slopes range from 30 to 70%. The Cryosolic soils are frozen to within 1 m of the surface throughout the year. The soils are imperfectly drained. The Engelmann spruce–subalpine fir/rock willow/white mountain heather v.t. is more abundant than Engelmann spruce–subalpine fir/feather-moss forest.

WILDLIFE

Table 104. Wildlife features of the SF1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
SF1	high	elk	medium	wolf cougar	medium	snowshoe hare red-backed vole porcupine	medium

SF1 is moderately important to all groups of wildlife. It is most important to large mammals in summer. Snow depths up to 0.8 m restrict large mammal movement in winter.

MANAGEMENT CONSIDERATIONS

Permafrost and solifluction in the active layer are the two main features that limit park uses to activities that do not disturb the insulation and thermal balance. Removal of vegetation and surface organic layers will increase the active layer depth, possibly resulting in slope failure. Road construction, in particular, should avoid SF1 tracts.

SP - SPRAY ECOSECTION

The Spray (SP) Ecosection encompasses glaciolacustrine landforms dominated by Luvisolic and Brunisolic soils and lodgepole pine forest in the Lower Subalpine portion of the Subalpine Ecoregion. Table 105 outlines the features of the SP1 Ecosite.

SP1 occupies valley floor and lower slope positions. Surficial veneers of Eolian

Fig. 29 Landscape schematic of the Snowflake 1 (SF1) Ecosite in relation to other Ecosites.

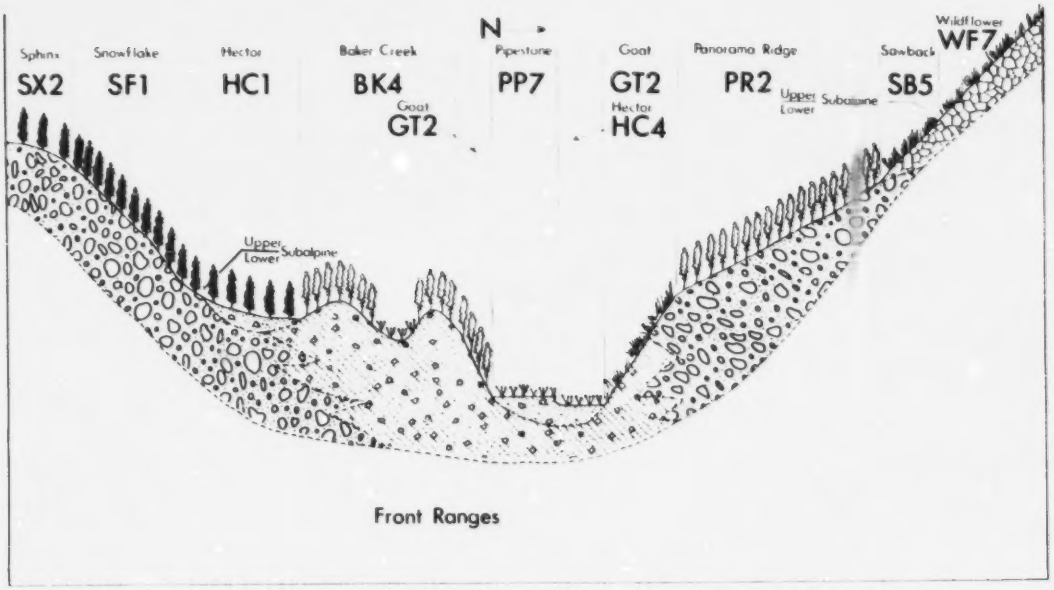


Table 105. General features of the SP1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
SP1	Glaciolacustrine veneer & blanket over undulating & hummocky glacial materials	Glaciolacustrine material (calcareous, fine textured) over Ice contact stratified Drift B (calcareous, variably textured)	Gray Luvisol, Eutric Brunisol	Lodgepole pine forest (C18, C19)

material B (altered, medium textured) occur occasionally. Slopes are between 2 and 15%. Soils are well to moderately well drained. On some SP1 tracts Till C (calcareous, medium textured) underlies the glaciolacustrine material.

WILDLIFE

Table 106. Wildlife features of the SP1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
SP1	medium	elk	medium	cougar	low	red squirrel	medium

This Ecosite is moderately important to wildlife. However, very few species occur here in high numbers. Snow depths up to 1.2 m restrict ungulate movement in winter.

MANAGEMENT CONSIDERATIONS

Even though SP1 is well to moderately well drained, the slow infiltration and permeability rates of the glaciolacustrine material will create problems wherever water can collect (e.g. depressions on trails). Removal of vegetation will significantly increase the chances for water and wind erosion, including slumps.

SX - SPHINX ECOSECTION

The Sphinx (SX) Ecosection encompasses moist to wet morainal landforms in the Upper Sublapine portion of the Subalpine Ecoregion. Soils are genetically related Gleysolics, gleyed Podzolics, and gleyed Brunisolics. Vegetation reflects varying seepage conditions and includes moist herb meadow, dwarf shrub-herb meadow, heath tundra, moist shrub thicket, wet shrub thicket, and Engelmann spruce-subalpine fir open forest. Table 107 outlines the features of the three SX Ecosites, seperated primarily by vegetational differences.

SX occurs on floors, benchlands, walls, and shoulders within valleys, cols, and cirques. Wetness is attributed to seasonal and episodic seepage giving imperfectly to poorly drained soils. The discontinuous fluviolacustrine material was derived locally by sheet erosion of morainal surfaces and reworking of postglacial eolian deposits. Solifluction is common, especially on SX1, and contributes to the occurrence of turbic phase soils. Slopes range from 5 to 45%.

WILDLIFE

SX is moderately important to wildlife. Some small mammals reach very high densities on SX Ecosites and, in addition, SX supports many species of small mammals. In summer, many areas in Jasper are highly important range for caribou. In winter, snow is too deep for ungulates to occur here.

Table 107 General features of the SX Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
SX1	Morainal blanket over inclined, hummocky, to ridged bedrock > fluviolacustrine veneer	Till B (noncalcareous, medium textured) > Fluviolacustrine material A (altered, fine-stratified)	Gleysol, gleyed Podzolic, Gleyed Dystric Brunisol	Moist herb meadow (H16), dwarf shrub-herb meadow (L7) > heath tundra (L5), wet shrub thicket (S8)
SX2	Morainal blanket over inclined, hummocky, & ridged bedrock > fluviolacustrine veneer	Till B & C (noncalcareous & calcareous, medium textured) > Fluviolacustrine material A (altered, fine-stratified)	Gleysol, gleyed Podzolic, Gleyed Dystric Brunisol	Engelmann spruce - subalpine fir open forest (09,010)
SX 3	Morainal blanket over inclined, hummocky & ridged bedrock > fluviolacustrine veneer	Till B & C (noncalcareous & calcareous, medium textured) > Fluviolacustrine material A (altered, fine-stratified)	Gleysol, gleyed Podzolic, Gleyed Eutric Brunisol	Moist shrub thicket (S4), wet shrub thicket (S8)

Table 108. Wildlife features of the SX Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
SX1	low	caribou	medium	weasel	high	dusky shrew hoary marmot columbian ground squirrel northern bog lemming long-tailed vole porcupine	low
SX2	medium	moose	high	marten weasel wolverine wolf coyote	medium	masked shrew columbian ground squirrel red-backed vole heather vole porcupine	medium
SX3	high	caribou bighorn sheep	medium		medium	beaver	high

MANAGEMENT CONSIDERATIONS

Imperfect to poor drainage resulting from seepage is the major factor limiting most park uses. Moist, herb dominated v.t.s may be expected to recover quickly after moderate disturbances but will not tolerate heavy or prolonged use. Solifluction is common locally and may limit some uses. Removal of vegetation is expected to increase erosion, particularly solifluction.

TA - TALBOT ECOSECTION

The Talbot (TA) Ecosection encompasses surficial eolian veneers overlying glacial deposits in the Montane Ecoregion. Regosolic soils dominate under white spruce forest, grassland, and low shrub-herb meadow vegetation. Table 109 separates the two TA Ecosites, primarily by vegetational differences. Landscape positions are shown in Fig. 16.

Table 109. General features of the TA Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
TA2	veneer over inclined bedrock	Eolian material A (calcareous, medium textured)	Regosol	Grassland (H6), low shrub-herb meadow (L1)
TA3	Veneer over glacial blanket over hummocky and ridged bedrock	Eolian material A (calcareous, medium textured) over Ice contact stratified Drift B (calcareous, variably textured).	Regosol > Eutric Brunisol	White spruce forest (C2, C26, C27)

TA occurs on lower slopes and benchlands of major river valleys. Slopes range from 30 to 70% on TA2, from 5 to 70% on TA3. Soils are extremely calcareous and rapidly to well drained. TA2 occurs only in Jasper and is most common on southerly and easterly facing erosional scarps. The white spruce/fern moss and white spruce/prickly rose/fern moss v.t.s of TA3 occur only in Jasper.

WILDLIFE

This Montane Ecosection is very important to wildlife. The grasslands are critical winter range for elk, deer and sheep in many areas. Very high densities of deer mice occur on TA2. Wolf, cougar, and coyote are attracted by the high prey densities. The relatively warm climate, shallow snow accumulation and patches of forest enhance attractiveness of to wildlife.

MANAGEMENT CONSIDERATIONS

Regosolic soils dominate and indicate current and recent eolian deposition. Removal of vegetation is likely to result in wind and water erosion. Steep slopes and droughty conditions compound such potential erosion problems. Vegetation of TA3 is more resilient than that of TA2, but removal of vegetation is also expected to result in wind and water erosion, particularly on steep slopes.

Table 110. Wildlife features of the TA Ecosites

Ecosite	Ungulates		Carnivores		Small Mammals		Birds
	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
TA2	very high	bighorn sheep mountain goat deer	medium	wolf cougar coyote	very high	deer mouse heather vole	medium
TA3	very high	elk bighorn sheep deer moose	high	cougar wolf coyote marten	medium	red squirrel	high

TK - TEKARRA ECOSECTION

The Tekarra (TK) Ecosection (Table 111) encompasses inclined landforms of noncalcareous, coarse textured colluvium in the Alpine Ecoregion. Dystric and Sombric Brunisols and Regosolics occur under heath tundra and mountain avens tundra.

Table 111. General features of the TK1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
TK1	Blanket, veneer over inclined bedrock	Colluvium A (noncalcareous, coarse textured)	Dystric & Sombric Brunisol, Regosol	Heath tundra (L5), mountain avens tundra (H1)

TK1 occurs on steep, usually linear slopes in Main Ranges areas that are geologically dominated by Gog Group quartzites. Surface veneers of Eolian material B (altered, medium textured) occur sporadically. Slopes commonly range from 45 to 100%. Soils are well drained. Colluvial processes are locally active and include avalanching and soil creep. Unvegetated portions may constitute up to 50% of TK1 tracts.

WILDLIFE

TK is of low importance to wildlife.

MANAGEMENT CONSIDERATIONS

Steep and locally unstable (colluviating) slopes are limiting factors to be considered for many park uses. Removal of vegetation is likely to result in water and gravity erosion. Vegetation is expected to recover slowly from disturbances. Stony surfaces (coarse fragments) will affect certain uses such as trails.

Table 112. Wildlife features of the TK1 Ecosite

Ecosite	Ungulates		Carnivores		Small Mammals		Birds
	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
TK1	low		low		low	pika	medium

TR - TYRRELL ECOSECTION

The Tyrrell (TR) Ecosection encompasses dry to moist, shrubland and grassland dominated, morainal landforms in the Upper Subalpine portion of the Subalpine Ecoregion. Both calcareous and noncalcareous, medium textured tills form the moraines. Soils are Eutric and Melanic Brunisols. The features of the two TR Ecosites are outlined in Table 113. Landscape positions are shown in Fig. 30.

Table 113. General features of the TR Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
TR1	Blanket, veneer over inclined, hummocky & ridged bedrock	Till B & C (non-calcareous & calcareous, medium textured)	Eutric Brunisol > Melanic Brunisol	Dry shrub thicket (S10), moist shrub thicket (S12), Engelmann spruce-subalpine fir open forest (O18)
TR2	Blanket, veneer over inclined, hummocky & ridged bedrock	Till B & C (non-calcareous & calcareous, medium textured)	Eutric & Melanic Brunisol	Grassy tundra (H4), dry grassland (H14)

TR occurs on most topographic positions and is most extensive in the Front Ranges in association with Mesozoic and adjacent strata. Wet terrain is important on some TR1 tracts where it is associated with fluvial materials along streams. Slopes generally range from 5 to 45% on TR1 and from 30 to 70% on TR2. Tundra vegetation, including the mountain avens-snow willow-moss campion, mountain avens-kobresia-bearberry, white mountain heather-mountain avens-snow willow and heather-everlasting v.t.s, is important locally on TR1. Exposure, steepness of slope, and southerly aspects account for the dominant grassy vegetation on TR2.

WILDLIFE

TR is highly important to wildlife, particularly large mammals in summer. In winter, deep snow precludes large mammal activity in many areas.

Fig. 30 Landscape schematic of the Tyrrell (TR) Ecosites in relation to other Ecosites

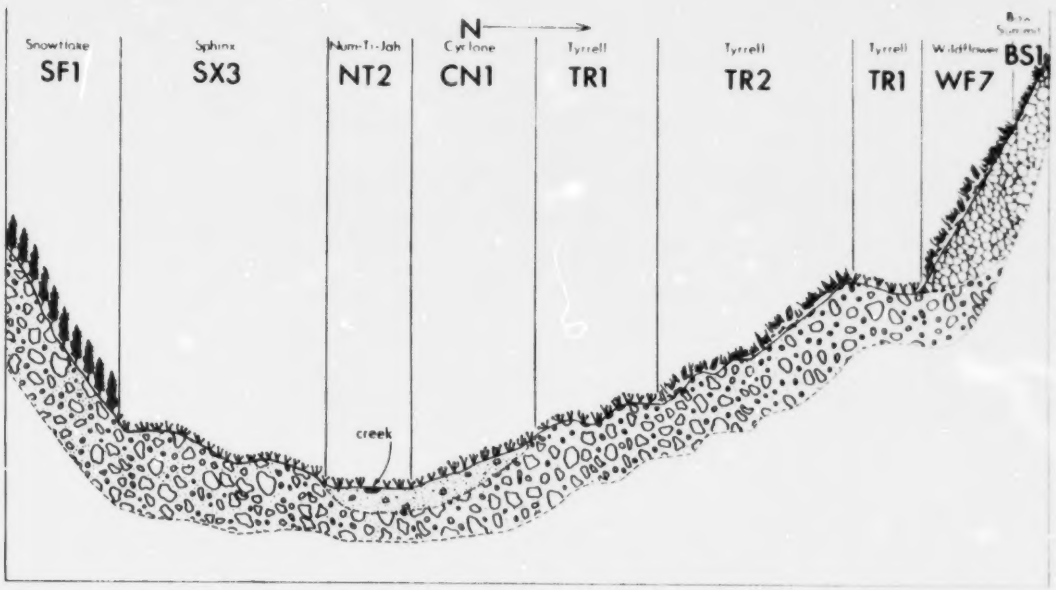


Table 114. Wildlife features of the TR Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
TR1	high	elk bighorn sheep	high	coyote wolf cougar	medium	least chipmunk hoary marmot	medium
TR2	high	elk bighorn sheep mountain goat caribou	high	coyote weasel cougar wolf	low		medium

MANAGEMENT CONSIDERATIONS

TR1 tracts with gentle slopes have no outstanding features limiting for park uses. Problems may arise with locally occurring features such as the complex tundra vegetation on hummock and ridge crests, wet terrain on depressional localities, and solifluction and cryoturbation on seepage affected sites.

On TR2 tracts, steepness of slope is the major factor to consider in planning of park uses. The degree of vegetation fragility is not known, but it is expected that vegetation recovers slowly after disturbance and that vegetation removal will significantly increase the chances of erosion. Droughty conditions compound potential revegetation problems.

TZ - TOPAZ ECOSECTION

The Topaz (TZ) Ecosection encompasses glacial and glaciofluvial landforms comprised of noncalcareous, coarse textured, ice contact stratified and glaciofluvial materials within the Lower Subalpine portion of the Subalpine Ecoregion. TZ is dominated by Dystric Brunisols and lodgepole pine forest. The features of the two TZ Ecosites, separated on the occurrence of a dry > wet versus an all dry landscape pattern, are outlined in Table 115. Landscape positions of the TZ Ecosites are shown in Fig. 8.

Table 115. General features of the TZ Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
TZ1	Ridged, hummocky & terraced	Ice contact stratified Drift A & Glaciofluvial material A (noncalcareous, coarse textured)	Dystric Brunisol	Lodgepole pine forest (C35, C19)
TZ2	Ridged, hummocky	Ice contact stratified Drift A (noncalcareous, coarse textured)	Dry 70: Dystric Brunisol Wet 30: Gleysol > Mesisol	Lodgepole pine forest (C35, C19) Wet Engelmann spruce - subalpine fir open forest (06), wet spruce open forest (011), wet shrubby meadow (S1), birch fen (S3)

TZ occurs on valley floors and lower slopes in the Main Ranges in Jasper, usually in association with Gog Group (quartzite) bedrock. Slopes range from 2 to 45% and are frequently channeled. Soils of the dry upland portions are rapidly drained; soils of wet depressions of TZ2 are imperfectly to very poorly drained. Lower B horizons of dry soils are often weakly cemented (duric tendency).

WILDLIFE

TZ is of moderate importance to wildlife. Only some small mammals occur here in high densities.

Table 116. Wildlife features of the TZ Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
TZ1	low		medium		medium	red squirrel red-backed vole heather vole	medium
TZ2	low		medium		low	snowshoe hare porcupine	low

MANAGEMENT CONSIDERATIONS

Both TZ Ecosites are of limited extent. Valley floor tracts with gentle slopes are convenient for many park uses, but other features should be considered. Coarse textured material provides gravel and sand for construction purposes, but such coarse textures are ineffective ion filters and thus present problems in sewage disposal. Abundant lichen vegetation occurs in some areas and is thought to be easily damaged and slow to recover from disturbances. Stony surfaces in some localities will affect trail and campsite construction. Characteristic dry > wet landscape pattern of TZ2 necessitates special considerations in planning certain park uses (e.g. trails).

VD - VERDANT ECOSECTION

The Verdant (VD) Ecosection encompasses fan and apron landforms consisting of noncalcareous, fluvial material within the Lower Subalpine portion of the Subalpine Ecoregion. It is dominated by Brunisolic soils with either spruce or pine forests. Table 117 outlines features of the VD Ecosites.

Table 117. General features of the VD Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
VD1	Fan, apron	Fluvial material A (noncalcareous, coarse-stratified)	Dystric Brunisol	Engelmann spruce-subalpine fir forest (C13, C14)
VD2	Fan, apron	Fluvial material A (noncalcareous, coarse-stratified)	Dystric Brunisol	Lodgepole pine forest (C19, C20)

VD occurs on lower slopes and valley floors. Veneers of Eolian material B (altered, medium textured) occur occasionally. Linear slopes between 2 and 30% are characteristic. Soil development reflects recent geomorphic stability. Soils are well to

moderately well drained.

WILDLIFE

Table 118. Wildlife features of the VD Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
VD1	low	moose	high	weasel lynx	high	snowshoe hare red squirrel red-backed vole	low
VD2	low	moose	high	marten weasel wolverine	low		low

VD is moderately important to wildlife. It is highly important to carnivores but of low importance to ungulates, birds and some small mammals.

MANAGEMENT CONSIDERATIONS

VD1 and VD2 tracts with gentle slopes generally have no characteristics limiting for campgrounds, trails, and related park uses. Locally occurring coarse textures and high water tables may present problems for sewage disposal, but the coarse textured material provides gravel for construction purposes.

EACH TRACT SHOULD BE EVALUATED IN DETAIL FOR SPECIFIC PROPOSED USES.

VL - VERMILION LAKES ECOSECTION

The Vermilion Lakes (VL) Ecosection encompasses wet fluvial and fluviolacustrine landforms on valley floors in the Montane Ecoregion. Gleysolic soils are characteristic but Organic soils and gleyed Regosol soils are common on some VL Ecosites. Vegetational features differentiate the four VL Ecosites (Table 119).

Wetness on VL results from high water tables and backwater flooding which causes imperfectly to very poorly drained soils. Fluvial material B on VL is low in coarse fragments. A low lime phase of Fluvial material B occurs in the Miette and Athabasca River valleys upstream from Jasper townsite. The interbedding of fluvial and fluviolacustrine materials on several VL Ecosites illustrates the dynamics of depositional environments over time. Soils in active or recently active sedimentation environments lack surface peat layers, whereas soils of geomorphically inactive localities have surface organic layers and include Mesisols on horizontal fens in ponded localities. VL1 and VL5 have the most abundant geomorphically active terrain. Slopes commonly range from 0 to 2% and are often channeled. VL1 is often ponded and small water bodies are common.

Table 119. General features of the VL Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
VL1	Level, horizontal fen	Fluviolacustrine material B (calcareous, fine-stratified), fen peat	Gleysol, Mesisol	Sedge fen (H11), wet shrubby meadow (S1), wet shrub thicket (S7)
VL3	Level	Fluvial material B (calcareous, coarse-stratified), Fluviolacustrine material B (calcareous, fine-stratified)	Gleysol	Wet white spruce forest (C4) > shrubby meadow (S1), wet shrub thicket (S7)
VL4	Level, apron, fan	Fluvial material B (calcareous, coarse-stratified), Fluviolacustrine material B (calcareous, fine-stratified)	Gleysol	Wet white spruce forest (C4)
VL5	Level, apron, fan	Fluvial material B (calcareous, coarse-stratified), Fluviolacustrine material B (calcareous, fine-stratified)	Gleysol > Gleyed Regosol	Wet shrub thicket (S7)

WILDLIFE

VL is very important to wildlife and is one of the most important in the two national parks. Critical winter range for elk and moose occurs here and many small mammal species reach high densities. Carnivores are attracted by these prey. Numerous bird species occur in the wetlands in high densities and many do not occur elsewhere in the parks. Uncommon raptors such as osprey and bald eagle nest in VL.

MANAGEMENT CONSIDERATIONS

Imperfect to very poor drainage, resulting from high water tables and backwater flooding, severely limits most park uses, unless expensive construction techniques are followed. On a number of VL tracts, particularly VL1, the flooding is accompanied by active sedimentation. Major construction activities (e.g. roads) on such tracts will change sedimentation and erosional patterns.

EACH TRACT SHOULD BE EVALUATED IN DETAIL FOR SPECIFIC PROPOSED USES.

WF - WILDFLOWER ECOSECOTION

The Wildflower (WF)Ecosection encompasses inclined landforms comprised of calcareous, medium textured colluvium in the Upper Subalpine portion of the Subalpine Ecoregion. Brunisolic and Regosolic soils dominate under avalanche complex v.t.s., Engelmann spruce-subalpine fir closed and open forest, mixed coniferous open forest, grassland, shrub thicket, and grassy tundra. Table 121 outlines five WF Ecosites separated primarily by vegetational differences.

Table 120. Wildlife features of the VL Ecosites

Ecosite	Ungulates		Carnivores		Small Mammals		Birds
	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
VL1	high	moose elk	medium	weasel wolf coyote	low	beaver meadow vole	very high
VL3	high	moose deer elk	high	wolf coyote weasel cougar lynx	high	snowshoe hare columbian ground squirrel red squirrel	high
VL4	high	moose elk deer	high	wolf coyote cougar lynx	high	dusky shrew snowshoe hare red squirrel deer mouse red-backed vole western jumping mouse	very high
VL5	high	moose elk	high	coyote wolf lynx cougar	high	masked shrew dusky shrew snowshoe hare red squirrel meadow vole	very high

Table 121. General features of the WF Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
WF1	Blanket, veneer over inclined bedrock	Colluvium C (calcareous, medium textured)	Eutric Brunisol, Regosol	Engelmann spruce - subalpine fir closed and open forest (C15, C21, O10)
WF2	Blanket, veneer over inclined bedrock, apron	Colluvium C (calcareous, medium textured	Eutric Brunisol, Regosol, Humic Regosol	Avalanche Complex 2 > Engelmann spruce - subalpine fir closed and open forest (C15, O10)
WF3	Blanket, veneer over inclined bedrock > inclined bedrock	Colluvium C (calcareous, medium textured	Eutric Brunisol, Regosol, Humic Regosol	Mixed coniferous open forest (O4) > Engelmann spruce - subalpine fir open forest (O10)
WF4	Blanket, veneer inclined bedrock	Colluvium C (calcareous, medium textured)	Eutric Brunisol, Regosol	Engelmann spruce forest (C33)
WF7	Blanket, veneer over inclined bedrock	Colluvium B & C (noncalcareous, medium textured)	Eutric & Melanic Brunisol, Humic Regosol	Grassland (H14), shrub thicket (S10), grassy tundra (H4)

WF occurs on or below steep valley walls and is associated with calcareous bedrock. Slopes generally range from 45 to 100%. Soils are rapidly to moderately well drained. Snow avalanching characteristically affects more than 50% of WF2. Unvegetated portions may constitute up to 50% of some WF2, WF3, and WF7 tracts. WF4 and WF7 occur primarily in the Front Ranges on dry, southerly aspets. WF3 is the steepest of the five WF Ecosites and has the greatest abundance of lithic soils and rock outcrops. Avalanche Complex 2, for WF2, is a heterogeneous complex of v.t.s. that includes subalpine fir-willow (S2), willow-dwarf birch-shrubby cinquefoil (SI0), juniper-willow (L2), hairy wild rye-wild strawberry-fireweed (H5), fleabane-valerian (H16), plus intergrades, with S2 being most abundant.

WILDLIFE

Table 122. Wildlife features of the WF Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
WF1	low		low	marten	medium		low
WF2	high	mountain goat bighorn sheep caribou	medium	wolverine	low	pika columbian ground squirrel golden-mantled ground squirrel	low
WF3	high	mountain goat bighorn sheep	low		medium	yellow pine chipmunk deer mouse	low
WF4	high	bighorn sheep mountain goat elk deer	medium	cougar wolf coyote	low	snowshoe hare	low
WF7	very high	bighorn sheep mountain goat elk	low	cougar	high	heather vole meadow vole long-tailed vole pika columbian ground squirrel	low

The importance of WF Ecosites to wildlife is variable. All but WF1 are highly important to ungulates. All Ecosites are of low importance to birds. To carnivores and small mammals the Ecosection is of low to moderate importance. Critical goat and sheep habitat occurs on WF2, WF3, WF4 and WF7.

MANAGEMENT CONSIDERATIONS

Steep and locally unstable (colluviating) slopes are limiting for many park uses. Snow avalanching, whether local (on WF1, WF3, WF4) or extensive (WF2), will affect winter uses. Shallow soils and bedrock outcrops on WF3 are factors to consider when planning certain uses (e.g. trails). Vegetation of WF3 recovers slowly from disturbances. WF4 is of limited areal extent. It is expected that vegetation on WF4 and WF7

recovers slowly from disturbances and that vegetation removal will significantly increase the chances of erosion, particularly colluviation. Droughty conditions on WF4 and WF7 will compound potential revegetation problems.

WH - WHITEHORN ECOSECTION

The Whitehorn (WH) Ecosection encompasses inclined landforms comprised of noncalcareous, medium textured colluvium in the Upper Subalpine portion of the Subalpine Ecoregion. Dystric Brunisols dominate under avalanche complex v.t.s., subalpine larch-subalpine fir forest, Engelmann spruce-subalpine fir closed and open forest, and mixed coniferous open forest. Table 123 outlines four WH Ecosites separated primarily by vegetational differences. Landscape position is shown in Fig. 31.

Table 123. General features of the WH Ecosites

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
WH1	Blanket, veneer over inclined bedrock	Colluvium B (noncalcareous, medium textured)	Dystric & Sombric Brunisol	Subalpine larch-subalpine fir forest (C23)
WH2	Blanket, veneer over inclined bedrock	Colluvium B (noncalcareous, medium textured)	Dystric Brunisol	Engelmann spruce-subalpine fir closed and open forest (C15, O10, C21)
WH3	Blanket, veneer over inclined bedrock, apron	Colluvium B (noncalcareous, medium textured)	Dystric & Sombric Brunisol > Humic Regosol	Avalanche Complex 2 > Engelmann spruce-subalpine fir closed and open forest (C15, O10)
WH5	Blanket, veneer over inclined bedrock > inclined bedrock	Colluvium B (noncalcareous, medium textured)	Dystric Brunisol > Regosol	Mixed coniferous forest (O4) > Engelmann spruce - subalpine fir open forest (O10)

WH occurs on or below steep valley walls and is associated with Miette Group or noncalcareous Mesozoic strata. Surface veneers of Eolian material B (altered, medium textured) occur sporadically. Slopes commonly range from 45 to 100%. Soils are rapidly to moderately well drained. Occurrences of subalpine larch-subalpine fir forest (C23) are restricted to southern Banff. Snow avalanching affects more than 50% of WH3. Unvegetated portions may constitute up to 50% of WH3 and WH5 tracts. WH5 is the steepest of the four WH Ecosites and has the greatest abundance of lithic soils and rock outcrops. Avalanche Complex 2, for WH3, is a heterogeneous complex of v.t.s. that includes subalpine fir-willow (S2), willow-dwarf birch-shrubby cinquefoil (S10), juniper-willow (L2), hairy wild rye-wild strawberry fireweed (H5), fleabane-valerian (H16), plus intergrades, with S2 being most abundant.

WILDLIFE

Overall, WH is of low importance to wildlife. However, avalanche slopes are highly important where they occur. Most areas are forested and receive deep snow which

Fig. 31 Landscape schematic of the Whitehorn (WH) Ecosite in relation to other Ecosites.

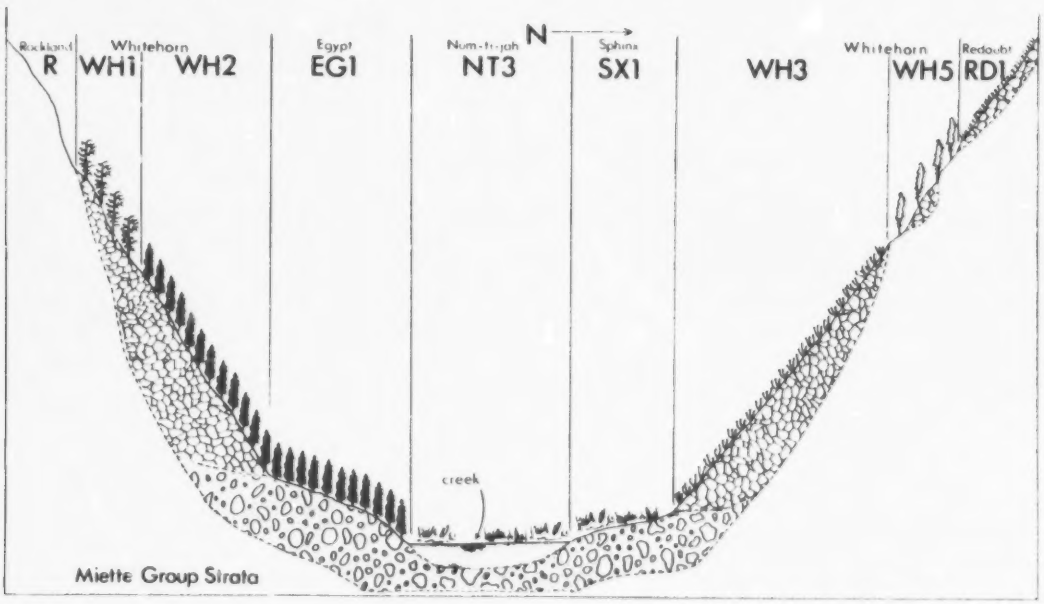


Table 124. Wildlife features of the WH Ecosites

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
WH1	low		low	marten	high	heather vole	low
WH2	high	elk	low		medium	pika	medium
WH3	low		low	marten	low	pika hoary marmot	low
WH5	low		low		low	dusky shrew heather vole pika hoary marmot columbian ground squirrel	high

limits the usefulness to large mammnals. Some small mammals reach high densities on some of the Ecosites.

MANAGEMENT CONSIDERATIONS

WH1 and WH2 are of limited areal extent. Steep and locally unstable (colluviating) slopes are limiting factors to be considered for many park uses. Snow avalanching, whether local (on WH1, WH2, WH5) or extensive (WH3), affects winter uses. The shallow soils and bedrock outcrops of WH5 are other factors to consider when planning some uses (e.g. trails). Vegetation on WH5 is expected to recover slowly from disturbances.

WW - WARWICK ECOSECTION

The Warwick (WW) Ecosection encompasses hummocky and ridged morainal landforms comprised of calcareous, medium textured till in the Lower Subalpine portion of the Subalpine Ecoregion. Regosolic soils are dominant under herb mat vegetation. Table 125 summarizes the WW1 Ecosite. WW1 is an uncommon Ecosite restricted to the Main Ranges near the Continental Divide and is associated with recently retreating glaciers.

Table 125. General features of the WW1 Ecosite

Ecosite	Surface Expression	Genetic Material Unit	Soils	Vegetation
WW1	Hummocky, ridged	Till C (calcareous, medium textured)	Regosol, Humic Regosol	Herb mat (H8)

WW1 tracts occur on valley bottoms and lower slopes. Ice Contact Stratified Drift B (calcareous, variably textured) is an accessory genetic material. Complex slopes range from 5 to 45%. Soils are moderately well drained and display incorporation of decomposing herb mat (H8) vegetation into the surface mineral horizon. The yellow dryad-willow herb v.t. is a community that pioneers neoglacial landscapes.

WILDLIFE

WW1 is of low importance to wildlife.

MANAGEMENT CONSIDERATIONS

WW1 is of limited areal extent. The dominant Regosolic soils indicate recent glacial deposition. Vegetation can probably withstand moderate use but once destroyed is expected to recover slowly. Of particular concern are steep slopes and imperfectly to poorly drained depressional localities. Areas of WW1 are ideal for research purposes in such fields as glacial geology and geomorphology, paleoclimatic studies, soil genesis, vegetational succession, and naturally disturbed site rehabilitation.

ECOSITE MODIFIERS

Ecosite Modifiers are applied to individual tracts which are not part of an Ecosite concept. The Ecosite Modifiers are listed below.

Table 126. Wildlife features of the WW1 Ecosite

	Ungulates		Carnivores		Small Mammals		Birds
Ecosite	Ranking	Important Species	Ranking	Important Species	Ranking	Important Species	
WW1	low		medium	marten weasel	low	golden-mantled ground squirrel deer mouse	low

A - AVALANCHED

The Ecosite Modifier **Avalanched** (A) is used with a map symbol when 20 to 50% of a tract is modified by frequent snow avalanches, an occurrence common to many Subalpine Ecosites. The avalanching has little direct effect on soils but is largely responsible for the following v.t.s: subalpine fir-willow (S2), willow-dwarf birch-shrubby cinquefoil (S10), juniper-willow (L2), hairy wild rye-wild strawberry-fireweed (H5), fleabane-valerian (H16), and aspen/hairy wild rye-showy aster (C22).

MANAGEMENT CONSIDERATIONS

Ecosites affected by avalanching require modified management considerations, particularly for winter uses.

B - BURNED

The Ecosite Modifier **Burned** (B) is used when 50% or more of the vegetation of a tract is modified by fire and is not a recognized v.t.

MANAGEMENT CONSIDERATIONS

Burned areas may be conducive to accelerated rates of erosion, especially in the few years immediately following fire. They are often favorable for wildlife since fire usually results in forest being replaced by herbaceous or shrubby vegetation. Also, burned areas may serve as a research sites to determine the pathways and rates of vegetational succession.

F - FAILED

The Ecosite Modifier **Failed** (F) is of three types: old (inactive) rock glaciers; areas of slow mass movement, guided by a slip surface; and areas of deep, extensive and severe solifluction.

MANAGEMENT CONSIDERATIONS

Failed tracts with old rock glacier landforms should not receive changed management consideration because the rock glaciers are not expected to reactivate. Failed terrain that includes mass movement and severe solifluction will influence management considerations for park uses. Such tracts should be evaluated individually to determine the

potential for further slope failure.

X - LITHIC

The Ecosite Modifier **Lithic** (X) is used when $\geq$ 50% of a tract is modified by shallow soils over bedrock, where the lithic contact is within the normal depth of the soil control section.

MANAGEMENT CONSIDERATIONS

Shallow soils and bedrock will change management considerations for Lithic Ecosites. Uses that require deep unconsolidated material (e.g. sewage disposal) will be precluded.

MISCELLANEOUS LANDSCAPES

CL - COLLUVIAL LANDSLIDE

The Miscellaneous Landscape **Colluvial Landslide** (CL) encompasses areas of sparsely vegetated landslide materialls. Deposited by rapid gravity-induced movement, these deposits are a chaotic, generally loose, mixture of soil and rubble from a variety of genetic material sources. Surface expression is irregular, usually hummocky. Nonsoil dominates the landscape, with Regosolic soils occurring in local areas. CL is characterized by >80% unvegetated terrain. The remaining 20% is sparsely vegetated with saxicolous lichen (H12), spotted saxifrage-hairy wild rye (H20), and mountain avens-snow willow-moss campion (H1) v.t.s.

MANAGEMENT CONSIDERATIONS

Irregular topography, lack of soil and rubbly, blocky surfaces are the major factors to consider as limitations for most park uses.

CR - COLLUVIAL RUBBLE

The Miscellaneous Landscape **Colluvial Rubble** (CR) is derived from Colluvium A, B, or C, depending on the characteristics of the source bedrock. Colluvial Rubble is a subset of *colluvium* as defined by C.S.S.C. (1978b) which results from slow, gravity-induced movement caused by surface creep, solifluction, and sheet erosion. Nonsoil dominates, but Regosolic soils occur locally. CR tracts may be unvegetated, or sparsely vegetated with saxicolous lichen (H12) and mountain avens-snow willow-moss campion (H1) v.t.s.

MANAGEMENT CONSIDERATIONS

Land stability, as well as lack of soil and vegetation, are major factors limiting most recreational park uses. The colluviation process is slower than for CL and thus, may permit some uses, (e.g. trails) but at significant development and maintenance costs.

GL - GLACIER

The Miscellaneous Landscape **Glacier** (GL) includes glacier, firn, ice field, and glacierette. GL tracts occur in all Ecoregions except the Montane and occur mostly near the Continental Divide. GL is unvegetated and nonsoil. Occasionally GL is mapped as a complex with other Miscellaneous Landscapes.

MANAGEMENT CONSIDERATIONS

GL areas have scientific, ecological, and tourist interest. The implications for use are complex and require site specific studies by qualified personnel. The ecological concerns involve long term climatic and hydrologic influences of the environment.

M - RECENT MORAINE

The Miscellaneous Landscape **Recent Moraine** (M) encompasses areas of sparsely vegetated till, primarily Till C (calcareous, medium textured), and occurs in the Subalpine and Alpine Ecoregions near the Continental Divide. Ice retreat from these areas is so recent that Regosols and nonsoil are characteristic. The yellow dryad–willow herb (H8) v.t. usually pioneers these neoglacial landscapes. M is occasionally mapped as a complex with other Ecosites and Miscellaneous Landscapes.

MANAGEMENT CONSIDERATIONS

Areas of Recent Moraine have scientific, ecological, and tourist interest, particularly for geomorphological and pedological studies, as well as paleoecological studies of vegetational succession. The lack of soil and vegetation preclude many recreational park uses.

P - PITS

The Miscellaneous Landscape **Pits** (P) include borrow pits and fills, gravel pits, quarries, and refuse disposal sites. Because of small size, many disturbed sites cannot be mapped.

MANAGEMENT CONSIDERATIONS

Some Pits have been used as overflow campgrounds. These highly disturbed areas could often benefit from reclamation to blend them into the landscape more aesthetically and restore their biological productivity

R - ROCKLAND

The Miscellaneous Landscape **Rockland** (R) is comprised of consolidated bedrock of all lithologies and occurs in all Ecoregions. It is predominantly nonsoil and unvegetated, although some high elevation tracts are sparsely vegetated with saxicolous lichen (H12) and mountain avens–snow willow–moss campion (H1) v.t.s. Some tracts also have stunted trees growing in cracks and shallow pockets of soil. R is occasionally mapped as a complex with other Ecosites and Miscellaneous Landscapes.

MANAGEMENT CONSIDERATIONS

Lack of soil and vegetation preclude many recreational park uses. Steepness and safety problems are other limitations to their use. Aesthetic values are high, as is their use for geological studies.

RG - ROCK GLACIER

The Miscellaneous Landscape **Rock Glacier** (RG) includes predominantly unvegetated masses of poorly sorted, angular coarse fragments and fine earth material, cemented

by interstitial ice a meter or more below the surface. It is a product of colluvial and glacial processes. RG is dominantly nonsoil, although Regosols do occur on older stable portions where vegetation has become established. RG is often mapped as a complex with Talus (T).

MANAGEMENT CONSIDERATIONS

RG areas are of scientific, ecological, and tourist interest. Steepness and lack of soil and vegetation are severely limiting factors for most recreational park uses.

SC - RECENT STREAM CHANNEL

The Miscellaneous Landscape **Recent Stream Channel** (SC) consists of level floodplains comprised primarily of calcareous, coarse textured glaciofluvial material in all Ecoregions. SC originates from glacial meltwater streams which are usually still rapidly aggrading. It is characterized by Regosolic and Gleysolic soils associated with sparsely or unvegetated sites. Pioneering v.t.s.,such as sedge-saxifrage (H3), herb mat (H8) and willow/horsetail (S7), occur in small, isolated patches. SC may also be mapped as a complex with other fluvial landscapes.

MANAGEMENT CONSIDERATIONS

Wetness, continuing landform building processes and, in some instances, flood hazard, are severe limitations to most park uses. SC tracts are ideal for studying vegetational succession, as well as for pedogenic studies.

T - TALUS

The Miscellaneous Landscape **Talus** (T) encompasses areas of a loose, angular, coarse fragment phase of either Colluvium A, B, or C, depending on the source lithology. Talus is a subset of *colluvium* as defined by C.S.S.C. (1978b) formed by gravitational falling, rolling, and sliding of individual fragments dislodged by physical weathering of steep, resistant rock walls. Talus is dominantly nonsoil and unvegetated, although a few tracts have Regosolic soils associated with sparse vegetation. It occurs in all Ecoregions and is occasionally mapped with other Miscellaneous Landscapes.

MANAGEMENT CONSIDERATIONS

Steepness, instability, and lack of soil and vegetation result in severe limitations for most recreational park uses.

W - WATER BODIES

The Miscellaneous Landscape **Water Bodies** (W) include named and unnamed lakes and ponds, both natural and artificial. The smallest Water Bodies shown are approximately 25 ha and are delineated at the high water level where seasonal fluctuations are evident. Water Bodies are mapped in all Ecoregions.

MANAGEMENT CONSIDERATIONS

Water bodies should be inventoried individually.

CHAPTER IV - RESOURCE USE INTERPRETATION [2]

W.D. Holland

INTRODUCTION

The soil, vegetation, and wildlife of the National Parks are natural resources which are studied to provide information useful in making decisions, with the expectation of a profitable return, social benefit, or reduction in the cost of management. The study and mapping of ecological (biophysical) resources serves this practical purpose by accumulating technical information on the natural resources and by providing this information for use in the planning and management of specific land areas or kinds of soil, vegetation, or wildlife.

This involves:

1. resource inventory – gathering basic information on the kinds, amounts, and distribution of soil, vegetation, and wildlife.
2. resource use interpretation – developing an interpretive classification
3. resource management plans – applying the interpretive classification to specific land areas and resources, and developing management plans.
4. resource management – operational application of the management plans

The primary purpose of the Banff–Jasper Ecological Land Classification has been resource inventory, and the maps and volumes of this report provide the basic resource information. This chapter deals with interpretive classification. The activities in points 3 and 4 above are beyond the scope of this report.

INTERPRETIVE CLASSIFICATION

Basic resource inventories contain a wealth of information which managers often find overwhelming in volume and detail. Therefore, it is necessary to simplify the information by grouping resource components into interpretive classes for specific purposes (Montgomery and Edminster 1966, Bauer 1973, Pettry and Coleman 1973, Zayach 1973, Westerveld and van den Hurk 1973). Each class contains resource components which have similar suitabilities or responses for a particular use or management. Thus, several Ecosites which have a similar suitability for trail use would be grouped into the same interpretive class. A range of classes, from high to low suitability, is developed for each specific use. Often the factors limiting suitability are noted as subclasses. For example, flooding may cause a low interpretive class rating for a particular Ecosite, while the low rating of another is due to excessive stoniness. Interpretive classifications are use specific and an Ecosite or land area which is rated low for one use may be rated high for others. Consequently, managers will need a series of interpretive classifications, all founded on the basic resource inventory, to make decisions involving various uses or management practices.

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[2] *Interpretation*, as used here, is the grouping of resource components on the basis of similar properties which affect their use. This is a different meaning of *interpretation* than often used by Parks Canada; this latter refers to the explanation of park features to visitors.

In making an interpretive classification, several principles should be observed:

1 Define clearly the purpose of each classification.

2 Classifications are generally based on the kinds and degree of limitation to a specific use. The ranges of the resource qualities which define the various classes should be defined as precisely as possible. Resource groupings are usually according to one resource quality.

3 Classifications generally contain few classes. An odd number of classes permits two extremes as well as a mean or average class, three to five being most common. More classes may be needed for intensive management, but a large number of classes becomes unwieldy and does little to help simplify the information.

4 The intensity of management for a particular classification must be stated because many limitations can be reduced by management. Thus, a factor, such as high tree density, which may be severely limiting in a backcountry campsite with a low intensity of management may present less severe limitations in a highly developed area where more in time management permits clearing of access roads, paths, and tent pads.

5 Interpretive classes are relative – good, fair, poor. Such groupings are dynamic and can be changed as situations change; for example, an altered management practice.

Examples of these principles applied to interpretive classifications based on soil limitations (Table 127) are in *Soils of Waterton Lakes National Park* (Coen and Holland 1976).

Table 127 Example interpretations of soil characteristics for selected park uses (Coen and Holland 1976)

Map Units	Degree and Nature of Limitations for Recreation Uses						Degree and Nature of Limitations for Engineering Uses						Susceptibility to water erosion
	Playgrounds		Camp Areas		Paths & Trails		Septic Tank Fields			Bldgs with Basements		Local Roads	
	slight	moder- severe ate	slight	moder- severe ate	slight	moder- severe ate	slight	moder- severe ate	pollution hazard	slight	moder- severe ate	slight	moder- severe ate
2 2 AC,AD	Stony	Slope CF[1] Moist		CF Moist Stony		CF Stony	nil		Fo		Stony	Stony		Low
1 1 DF,FF, 1 F	Stony	Slope CF Moist		Slope Moist Stony CF		Slope Stony CF		Slope	Fo		Stony Slope		Slope	Low
1 1 F,C, 1 DE	Stony	Slope CF Moist		Stony Slope CF Moist		Stony Slope CF		Stony Slope	Fo		Stony Slope		Slope	Moderate
15 AB	Flood Wet			Flood		Flood		W.T Flood			Wet W.T. Str Flood		Flood Frost Str	Low
17 17 AC,AD		Moist CF		CF Moist	nil		nil		Fo	nil		nil		Low
21 AC		CF Moist		CF Moist		CF	nil		Fo	Stony		Stony		Moderate
21 F		CF Moist		CF Moist Slope		Slope CF		Slope	Fo		Slope		Slope	High
91 AB		wet Flood		Wet Flood		Wet Flood	Perm	W.T. Flood			Sh-Sw Wet, Str W.T. Frost Flood		Sh-Sw Wet Frost Flood Str	Low

[1] Abbreviations as follows: CF = Coarse fragments, Stony = Surface stoniness, Moist = Useful moisture; Slope = % slope; Fo = Pollution hazard; Flood = Flooding, Wet = Wetness (soil drainage); W.T. = Depth to seasonal water table, Str = Strength of soil as rated by Unified or AASHO; Frost = Susceptibility to frost heave, Perm = Permeability, Sh-Sw = Shrink-swell potential

Much of the interpretive information in the *Management Considerations* section of the Ecosection descriptions in this volume is based on soils. Procedures similar to those in Table 127 can be applied to vegetation and wildlife information as well. Much of the interpretive classification of soils is based on physical characteristics which have been well investigated by engineering research. However, comparatively little research has been done on the response of vegetation and wildlife to various uses and intensities of management. Thus, making realistic predictions of responses for all Ecosites is not possible within the framework of this study. Lacking such information, it is possible to make only limited interpretations based on the response of Ecosites

which are currently receiving certain types and intensities of use. For example, if an area of a certain Ecosite is being used as a campsite and is deteriorating, one can assume that other areas of the Ecosite which receive the same type and intensity of use and management would also deteriorate. Such a limited interpretation would not apply to any other than this specific Ecosite.

Interpretive classifications may be presented either as tables (Coen and Holland 1976) or maps (Lindsay et al. 1973) in which areas with similar capability and limitation are designated with a common symbol. The single factor maps prepared by Kurt Seel of Parks Canada, Western Region, Calgary, are examples of interpretations that are effective for planning because the maps are easily understood.

Interpretive classifications also have limitations:

1. It is assumed that enough is known about the effects on a resource component of a certain use or management practice to accurately assess suitability. Such information is rarely as complete as desired. Thus, interpretive classifications are always subject to revision as new knowledge becomes available.
2. The boundaries on interpretive maps do not separate resource components or Ecosites *per se*, but are based on resource characteristics which significantly affect the specific use being examined.
3. An interpretive classification can be used only for the specific use for which it was developed. If information on another use is needed, a new grouping must be derived using the basic resource information.
4. The person developing an interpretive classification must be aware of the limitations of the basic resource inventory information. It is relatively easy to go beyond that range of validity of the data. Scale, in particular, must be carefully considered. Resource information in this report is presented at a scale of 1:50,000. Many land management decisions will require site specific investigation to determine if the broader scale interpretive class based on an Ecosite in this report is appropriate for a smaller specific area.

Four sources of information for an interpretive classification are:

1. Field data gathered during the inventory stage to describe classify, and quantify natural resources such as landforms, soils, vegetation, and wildlife.
2. Research plot studies testing the response of key soils, vegetation types or wildlife habitats to various management practices, e.g. irrigation, fertilizing, planting, cutting or burning.
3. Indirect evaluations estimating use suitability of unknown resources by comparing them with those for which information is available.
4. User experience utilized to determine the nature and degree of resource use suitability or limitation of tracts known to represent a particular Ecosite concept. Especially helpful experience may be that of wardens, naturalists or other personnel with extensive experience in National Parks.

Information about an Ecosite, derived from one or more of these four sources, can then be used to develop predictions about the response of other tracts mapped as that Ecosite to the use under consideration.

Generally, application of the predictions involves three steps:

1. All the natural resources are listed. This will usually be a listing of all the map symbols which represent unique tracts of land.
2. All data describing the natural resources are assembled. Items frequently affecting parks use often include, for example, slope, aspect, elevation, vegetation type, snow depth, and various aspects of wildlife use.
3. Using the principles identified above, the data are grouped into classes based on the information associated with each map symbol listed in 1 above. A five class rating might be:
   - G = Good (slight limitations)
   - F = Fair (moderate limitations)
   - P = Poor (severe limitations)
   - V = Very Poor (very severe limitations)

U = Unsuitable

The following demonstrates the interpretive classification process. In this example, the objective is to locate campground sites that can accomodate 2,000 people per night. The selection criteria for large campgrounds first must be established and then the land inventory data searched. Selection criteria might include:

1. Snow avalanche risk
2. Flooding hazard
3. Slope of the landform
4. Soil attributes which affect revegetaion, dustiness or ease of foot travel
5. V.t.s that affect ground cover, shade, screening, resistance to use or rapid recovery after use.
6. Wildlife attributes, such as use for winter range, calving, denning, nesting or migration
7. Size limits which affect use of the tract
8. Compatability with adjacent land uses.

The nature and degree of the limitation, as judged by the above selection criteria, determines to which of the five classes (Good to Unsuitable) a tract will be assigned. The guidelines established here should be carefully recorded so that as knowledge improves, the class limits can be reassessed.

Land classification maps and accompanying information can be stored by computers. Programs are being developed to allow planning teams to alter guidelines and then assess the effect of this alteration on the class limits of interpretive maps. This approach allows the development of a set of scenarios representing several proposed management or design alternatives.

There is no best way to interpret basic ecological inventory data. The foregoing outlines several principles and an example of one appraoch to analyzing inventory data. The method chosen however, must recognize the spatial limitations of the data and the reliability limits of the analytical data about Ecosites upon which responses are predicted.

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72. Stands representing the juniper-willow (L2) v.t.
73. Stands representing the white mountain heather-mountain avens-snow willow (L4) v.t.
74. Stands representing the heather-everlasting (L5) v.t.
75. Stands representing the creeping juniper-wheatgrass-sedge (L6) v.t.
76. Stands representing the arctic willow-cinquefoil (L7) v.t.
77. Stands representing the mountain avens-snow willow-moss campion (H1) v.t.
78. Stands representing the black alpine sedge-everlasting (H2) v.t.
79. Stands representing the sedge-saxifrage (H3) v.t.
80. Stands representing the mountain avens-kobresia-bearberry (H4) v.t.
81. A stand representing the hairy wild rye-wild strawberry-fireweed (H5) v.t.
82. Stands representing the junegrass-pasture sage-wild blue flax (H6) v.t.
83. Stands representing the wheatgrass-pasture sage (H7) v.t.
84. Stands representing the yellow dryad-willowherb (H8) v.t.
85. Stands representing the mountain marigold-globeflower (H9) v.t.
86. Stands representing the cottongrass/moss (H10) v.t.
87. Stands representing the water sedge-beaked sedge (H11) v.t.
88. Stands representing the saxicolous lichen (H12) v.t.
89. Stands representing the Richardson needlegrass-junegrass-everlasting (H13) v.t.
90. Stands representing the hairy wild rye-junegrass-bearberry (H14) v.t.
91. Stands representing the mountain avens-curly sedge (H15) v.t.
92. Stands representing the fleabane-valerian (H16) v.t.
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95. Organization of Ecosections by Ecoregion and genetic material classes.
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97. Example of Ecosite separations within an Ecosection.
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99. Pedon (Alberta 1974 No. 105) description of an Orthic Eutric Brunisol of the AL1 Ecosite.
100. Stand (AW5009) illustrating the lodgepole pine/buffaloberry/twinflower (C19) v.t. of the AL1 Ecosite.
101. Pedon (Alberta 1978 No. 216) description of an Orthic Eutric Brunisol of the AL2 Ecosite.
102. Stand (JC8081) illustrating the Engelmann spruce-subalpine fir/feathermoss (C13) v.t. of the AL2 Ecosite.
103. General features of the Athabasca (AT) Ecosites.
104. Pedon (Alberta 1977 No. 132) description of an Eluviated Eutric Brunisol of the AT1 Ecosite.
105. Stand (JD7114) illustrating the lodgepole pine/juniper/bearberry (C3) v.t. of the AT1 Ecosite.
106. Pedon (Alberta 1976 No. 70) description of an overblown phase of an Orthic Melanic Brunisol representing soil of the AT3 Ecosite.
107. Stand (IC5003) illustrating the junegrass-pasture sage-wild blue flax (H6) v.t. of the AT3 Ecosite.
108. General features of the Azure 1 (AZ1) Ecosite.

109. Pedon (Alberta 1979 No. 38) description of an Eluviated Dystric Brunisol of dry upland segments of the AZ1 Ecosite.
110. Stand (JE9043) illustrating the Engelmann spruce-subalpine fir/heather (O10) v.t. of dry upland segments of the AZ1 Ecosite.
111. General features of the Baker Creek (BK) Ecosites.
112. Pedon (Alberta 1975 No. 350) description of Brunisolic Gray Luvisol of dry upland segments of the BK1 Ecosite.
113. Pedon (Alberta 1978 No. 22) description of a Rego Gleysol in wet depressional segments of the BK1 Ecosite.
114. Stand (JD6094) illustrating the lodgepole pine/buffaloberry/grouseberry (C18) v.t. of dry upland segments of the BK1 Ecosite.
115. Stand (IC8095) illustrating the spruce/Labrador tea/brown moss (O11) v.t. of wet depressional segments of the BK1 Ecosite.
116. Pedon (Alberta 1979 No. 94) description of an Eluviated Eutric Brunisol of dry upland segments of the BK4 Ecosite.
117. Stand (JE8021) illustrating the lodgepole pine/buffaloberry/twinflower (C19) v.t. of dry upland segments of the BK4 Ecosite.
118. Stand (PA7016) illustrating the dwarf birch-shrubby cinquefoil/needlerush (S3) v.t. of wet depressional segments of the BK4 Ecosite.
119. Stand (PA8109) illustrating the dwarf birch-shrubby cinquefoil-willow/brown moss (S1) v.t. of wet depressional segments of the BK6 Ecosite.
120. General features of the Boulder Pass (BP) Ecosites.
121. Pedon (Alberta 1979 No. 20) description of an Orthic Eutric Brunisol of the BP1 Ecosite.
122. Stand (JE9164) illustrating the Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) v.t. of the BP1 Ecosite.
123. Pedon (Alberta 1978 No. 36) description of an Eluviated Eutric Brunisol of the BP2 Ecosite.
124. Stand (JE8151) illustrating the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. of the BP2 Ecosite.
125. General features of the Bow Summit (BS1) Ecosite.
126. Pedon (Alberta 1978 No. 25) description of an Orthic Melanic Brunisol of the BS1 Ecosite.
127. Stand (JC6025) illustrating the mountain avens-snow willow-moss campion (H1) v.t. of the BS1 Ecosite.
128. General features of the Bow Valley (BV) Ecosites.
129. Pedon (Alberta 1976 No. 63) description of an Eluviated Eutric Brunisol of the BV1 Ecosite.
130. Stand (LC9180) illustrating the lodgepole pine/buffaloberry/twinflower (C19) v.t. of the BV1 Ecosite.
131. Pedon (Alberta 1975 No. 107) description of an Eluviated Eutric Brunisol of the BV2 Ecosite.
132. Stand (AW5177) illustrating the lodgepole pine/false azalea/grouseberry (C20) v.t. of the BV2 Ecosite.
133. Stand (IC6100) illustrating the Engelmann spruce-subalpine fir/feathermoss (C13) v.t. of the BV3 Ecosite.
134. General features of the Bryant (BY) Ecosites.
135. Pedon (Alberta 1978 No. 38) description of an Eluviated Eutric Brunisol of the BY1 Ecosite.
136. Stand (JD7021) illustrating the Engelmann spruce-subalpine fir/false azalea (C14) v.t. of the BY1 Ecosite.
137. Pedon (Alberta 1979 No. 91) description of an Orthic Eutric Brunisol of the BY2 Ecosite.
138. Stand (JD9082) illustrating the Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t. of the BY2 Ecosite.
139. Pedon (Alberta 1978 No. 81) description of an Orthic Eutric Brunisol of the BY4 Ecosite.
140. Stand (AW7085) illustrating the Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) v.t. of the BY4 Ecosite.
141. General features of the Brazeau (BZ) Ecosites.
142. Pedon (Alberta 1977 No. 118) description of an Eluviated Dystric Brunisol of the BZ1 Ecosite.
143. Stand (CC6068) illustrating the Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t. of the BZ1 Ecosite.
144. Stand (JC7103) illustrating the lodgepole pine/Labrador tea (C29) v.t. of the BZ2 Ecosite.
145. General features of the Cavell (CA) Ecosites.
146. Pedon (Alberta 1977 No. 143) description of gleyed Podzolic soil of wet segments of the CA1 Ecosite.
147. Stand (AW5017) illustrating the dwarf birch-shrubby cinquefoil-willow/brown moss (S1) v.t. of wet segments of the CA1 Ecosite.
148. Pedon (Alberta 1979 No. 78) description of an Eluviated Dystric Brunisol of the CA2 Ecosite.
149. Stand (JE9180) illustrating the Engelmann spruce-subalpine fir/false azalea (C14) v.t. of the CA2 Ecosite.
150. Pedon (Alberta 1979 No. 34) description of an Eluviated Dystric Brunisol of the CA4 Ecosite.
151. Stand (JD9030) illustrating the lodgepole pine/false azalea/grouseberry (C20) v.t. of the CA4 Ecosite.
152. General features of the Cyclone 1 (CN1) Ecosite.
153. Pedon (Alberta 1978 No. 51) description of a Cumulic Regosol of the CN1 Ecosite.

154. Stand (JC8076) illustrating the willow/hairy wild rye (S12) v.t. of the CN1 Ecosite.
155. General features of the Copper 1 (CP1) Ecosite.
156. Pedon (Alberta 1977 No. 139) description of an Orthic Dystric Brunisol of the CP1 Ecosite.
157. Stand (PA7185) illustrating the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. of the CP1 Ecosite.
158. General features of the Consolation Valley 1 (CV1) Ecosite.
159. Pedon (Alberta 1975 No. 110) description of a Terric Mesisol of wet segments of the CV1 Ecosite.
160. Pedon (Alberta 1977 No. 115) description of a Rego Gleysol of wet segments of the CV1 Ecosite.
161. Stand (KS5091) illustrating the Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14) v.t. of wet segments of the CV1 Ecosite.
162. General features of the Devona (DV) Ecosites.
163. Pedon (Alberta 1976 No. 66) description of an Orthic Regosol of the DV1 Ecosite.
164. Stand (JC7037) illustrating the creeping juniper-wheatgrass-sedge (L6) v.t. of the DV1 Ecosite.
165. Pedon (Alberta 1978 No. 17) description of a Cumulic Regosol of the DV2 Ecosite.
166. Stand (JM8001) illustrating the white spruce/prickly rose/fern moss (C27) v.t. of the DV2 Ecosite.
167. General features of the Eiffel 1 (EF1) Ecosite.
168. Pedon (Alberta 1979 No. 48) description of an Orthic Ferro-Humic Podzol of the EF1 Ecosite.
169. Stand (PA9129) illustrating the heather-everlasting (L5) v.t. of the EF1 Ecosite.
170. General features of the Egypt (EG) Ecosites.
171. Pedon (Alberta 1976 No. 98) description of an Orthic Dystric Brunisol of the EG1 Ecosite.
172. Stand (AW6092) illustrating the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. of the EG1 Ecosite.
173. Pedon (Alberta 1977 No. 137) description of an Orthic Humo-Ferric Podzol of the EG2 Ecosite.
174. Stand (JD6086) illustrating the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. of the EG2 Ecosite.
175. Pedon (Alberta 1978 No. 41) description of an Orthic Dystric Brunisol of the EG4 Ecosite.
176. Stand (JE8159) illustrating the heather-everlasting (L5) portion of the v.t. pattern of the EG4 Ecosite.
177. General features of the Endless Chain (EN) Ecosites.
178. Pedon (Alberta 1978 No. 80) description of an Eluviated Dystric Brunisol of the EN1 Ecosite.
179. Stand (JC8095) illustrating the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. of the EN1 Ecosite.
180. Pedon (Alberta 1979 No. 71) description of an Eluviated Dystric Brunisol of the EN2 Ecosite.
181. Stand (LC9171) illustrating the subalpine fir-willow (S2) v.t. of the EN2 Ecosite.
182. Pedon (Alberta 1978 No. 59) description of an Eluviated Dystric Brunisol of the EN3 Ecosite.
183. Stand (PA8157) illustrating the Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) v.t. of the EN3 Ecosite.
184. General features of the Fireside 1 (FR1) Ecosite.
185. Pedon (Alberta 1978 No. 89) description of an Orthic Eutric Brunisol of the FR1 Ecosite.
186. Stand (JD8003) illustrating the lodgepole pine/buffaloberry/showy aster (C6) v.t. of the FR1 Ecosite.
187. General features of the Fairview (FV) Ecosites.
188. Pedon (Alberta 1978 No. 70) description of an Eluviated Dystric Brunisol of the FV1 Ecosite.
189. Stand (DJ8001) illustrating the subalpine fir-willow (S2) v.t. of the FV1 Ecosite.
190. Pedon (Alberta 1978 No. 83) description of an Eluviated Dystric Brunisol of the FV2 Ecosite.
191. Stand (JE8165) illustrating the Engelmann spruce-subalpine fir/feathermoss (C13) v.t. of the FV2 Ecosite.
192. General features of the Garonne 1 (GA1) Ecosite.
193. Pedon (Alberta 1978 No. 65) description of Orthic Eutric Brunisols of the GA1 Ecosite.
194. Stand (JE8004) illustrating the lodgepole pine/buffaloberry/twinflower (C19) v.t. of the GA1 Ecosite.
195. General features of the Goat (GT) Ecosites.
196. Pedon (Alberta 1979 No. 68) illustrating Orthic Regosols of the GT1 Ecosite.
197. Stand (LC9183) illustrating an open variant of the lodgepole pine/juniper/bearberry (C3) v.t. of the GT1 Ecosite.
198. Pedon (Alberta 1979 No. 84) description of an Orthic Humic Regosol of southerly aspect segments of the GT2 Ecosite.
199. Stand (JD9075) illustrating the shrubby cinquefoil/bearberry-northern bedstraw (L1) v.t. of southerly aspect segments of the GT2 Ecosite.
200. General features of the Hector (HC) Ecosites.
201. Pedon (Alberta 1978 No. 68) description of a Rego Gleysol of the HC1 Ecosite.
202. Stand (JE8133) illustrating the Engelmann spruce/horsetail/feathermoss (C32) v.t. of the HC1 Ecosite.
203. Pedon (Alberta 1978 No. 90) description of a Rego Gleysol of the HC2 Ecosite.
204. Stand (JD7051) illustrating a bryoid-poor phase of the water sedge-beaked sedge (H11) v.t. of the HC2 Ecosite.
205. Pedon (Alberta 1979 No. 44) description of a Rego Gleysol of the HC4 Ecosite.

206. Pedon (Alberta 1979 No. 36) description of a Terric Mesisol of the HC4 Ecosite.
207. Stand (PA9124) illustrating the dwarf birch-shrubby cinquefoil-willow/brown moss (S1) v.t. of the HC4 Ecosite.
208. Stand (LC9162) illustrating the dwarf birch-shrubby cinquefoil/needlerush (S3) v.t. of the HC4 Ecosite.
209. General features of the Hillsdale (HD) Ecosites.
210. Pedon (Alberta 1977 No. 138) description of a Cumulic Regosol of the HD1 Ecosite.
211. Stand (PA7175) illustrating the aspen/hairy wild rye-peavine (C16) v.t. of the HD1 Ecosite.
212. Pedon (Alberta 1978 No. 18) description of a Cumulic Regosol of the HD2 Ecosite.
213. Stand (SJ8003) illustrating the white spruce/shrubby cinquefoil/bearberry (O3) v.t. of the HD2 Ecosite.
214. Pedon (Alberta 1978 No. 99) description of a Cumulic Regosol of the HD3 Ecosite.
215. Stand (PA8165) illustrating the white spruce-Douglas fir/feathermoss (C5) v.t. of the HD3 Ecosite.
216. Pedon (Alberta 1975 No. 115) description of a Cumulic Regosol of the HD4 Ecosite.
217. Stand (IC5010) illustrating the june grass-pasture sage-wild blue flax (H6) v.t. of the HD4 Ecosite.
218. General features of the Heather (HE) Ecosites.
219. Pedon (Alberta 1977 No. 129) description of an Orthic Dystric Brunisol, lithic and turbic phase, of the HE1 Ecosite.
220. Stand (PA7119) illustrating white mountain heather-mountain avens-snow willow, (L4), an accessory v.t. of the HE1 Ecosite.
221. Pedon (Alberta 1976 No. 999) description of an Orthic Regosol, lithic phase, of the HE2 Ecosite.
222. Stand (JC6051) illustrating the mountain avens-snow willow-moss campion (H1) v.t. on vegetated portions of the HE2 Ecosite.
223. General features of the Ishbel (IB) Ecosites.
224. Pedon (Alberta 1979 No. 70) description of an Eluviated Eutric Brunisol of the IB1 Ecosite.
225. Stand (LC9186) illustrating the lodgepole pine/buffaloberry/grouseberry (C18) v.t. of the IB1 Ecosite.
226. Pedon (Alberta 1978 No. 49) description of an Orthic Regosol of the IB2 Ecosite.
227. Stand (SJ9123) illustrating the white spruce/juniper/bearberry (O17) v.t. of the IB2 Ecosite.
228. Pedon (Alberta 1978 No. 26) description of an Eluviated Eutric Brunisol of the IB3 Ecosite.
229. Stand (JM8114) illustrating the Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) v.t. of the IB3 Ecosite.
230. General features of the Jonas 1 (JN1) Ecosite.
231. Pedon (Alberta 1977 No. 128) description of an Eluviated Dystric Brunisol of the JN1 Ecosite.
232. Stand (PA7143) illustrating the heather-everlasting (L5) v.t. of the JN1 Ecosite.
233. General features of the Katherine 1 (KA1) Ecosite.
234. Pedon (Alberta 1979 No. 90) description of a Cumulic Humic Regosol of the KA1 Ecosite.
235. Stand (JD9081) illustrating the arctic willow-cinquefoil (L7) v.t. of the KA1 Ecosite.
236. General features of the Larch Valley (LV) Ecosites.
237. Pedon (Alberta 1978 No. 96) description of an Eluviated Dystric Brunisol of the LV1 Ecosite.
238. Stand (JE8157) illustrating the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. of the LV1 Ecosite.
239. Pedon (Alberta 1979 No. 45) description of an Eluviated Dystric Brunisol of the LV2 Ecosite.
240. Stand (PA9125) illustrating the Engelmann spruce-subalpine fir/heather (O10) portion of the v.t. pattern of the LV2 Ecosite.
241. Pedon (Alberta 1979 No. 52) description of an Eluviated Dystric Brunisol of the LV3 Ecosite.
242. Stand (JC7080) illustrating the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. of the LV3 Ecosite.
243. General features of the Merlin Castle 1 (MC1) Ecosite.
244. Pedon (Alberta 1977 No. 126) description of a Gleyed Eutric Brunisol of wet segments of the MC1 Ecosite.
245. Stand (AW7073) illustrating the spruce/Labrador tea/brown moss (O11) v.t. of wet segments of the MC1 Ecosite.
246. General features of the Moraine Lake (ML) Ecosites.
247. Pedon (Alberta 1974 No. 124) description of an Eluviated Dystric Brunisol of the ML1 Ecosite.
248. Stand (KS5052) illustrating the Engelmann spruce-subalpine fir/false azalea (C14) v.t. of the ML1 Ecosite.
249. Pedon (Alberta 1979 No. 60) description of an Eluviated Dystric Brunisol of the ML2 Ecosite.
250. Stand (IC6003) illustrating the lodgepole pine/false azalea/grouseberry (C20) v.t. of the ML2 Ecosite.
251. Stand (IC5073) illustrating the Engelmann spruce-whitebark pine/false azalea (C12) v.t. of the ML3 Ecosite.
252. General features of the Molar Pass 1 (MP1) Ecosite.
253. Pedon (Alberta 1979 No. 92) description of an Orthic Eutric Brunisol of the MP1 Ecosite.
254. Stand (JD9083) illustrating the mountain avens-snow willow-moss campion (H1) v.t. of the MP1 Ecosite.
255. General features of the Mosquito 1 (MQ1) Ecosite.
256. Pedon (Alberta 1977 No. 159) description of an Orthic Eutric Brunisol of the MQ1 Ecosite.
257. Stand (PA7186) illustrating the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. of the MQ1 Ecosite.

258. General features of the Nigel 1 (NG1) Ecosite.
259. Pedon (Alberta 1979 No. 86) description of an Eluviated Eutric Brunisol of the NG1 Ecosite.
260. Stand (JD9077) illustrating the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. of the NG1 Ecosite.
261. General features of the Nashan 1 (NH1) Ecosite.
262. Pedon (Alberta 1979 No. 28) description of a Rego Gleysol from wet segments of the NH1 Ecosite.
263. Pedon (Alberta 1979 No. 29) description of a Brunisolic Gray Luvisol from dry upland segments of the NH1 Ecosite.
264. Stand (JD9021) illustrating the spruce/Labrador tea/brown moss (O11) v.t. of wet segments of the NH1 Ecosite.
265. General features of the Num-Ti-Jah (NT) Ecosites.
266. Pedon (Alberta 1979 No. 77) describing a Rego Gleysol of the NT2 Ecosite.
267. Stand (IC6021) illustrating the willow-cinquefoil (S8) v.t. of the NT2 Ecosite.
268. Pedon (Alberta 1979 No. 50) describing a Terric Mesisol of the NT3 Ecosite.
269. Stand (SJ9134) illustrating the water sedge-beaked sedge (H11) v.t. of the NT3 Ecosite.
270. General features of the Norquay (NY) Ecosites.
271. Pedon (Alberta 1977 No. 141) describing an Orthic Eutric Brunisol of the NY1 Ecosite.
272. Stand (PA7193) illustrating the lodgepole pine/buffaloberry/showy aster (C6) v.t. of the NY1 Ecosite.
273. Pedon (Alberta 1978 No. 85) describing an Orthic Eutric Brunisol of northerly aspect segments of the NY3 Ecosite.
274. Pedon (Alberta 1978 No. 84) describing an Orthic Regosol of southerly aspect segments of the NY3 Ecosite.
275. Stand (JC8002) illustrating the white spruce-Douglas fir/feathermoss (C5) v.t. of northerly aspect segments of the NY3 Ecosite.
276. Stand (JC8001) illustrating limber pine-Douglas fir/juniper/bearberry (O2), an accessory v.t. of southerly aspect segments of the NY3 Ecosite.
277. General features of the Peyto Lake (PL) Ecosites.
278. Pedon (Alberta 1977 No. 147) describing an Orthic Eutric Brunisol of the PL1 Ecosite.
279. Stand (AW5137) illustrating the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. of the PL1 Ecosite.
280. Pedon (Alberta 1978 No. 79) description of an Eluviated Eutric Brunisol of the PL3 Ecosite.
281. Stand (JE8161) illustrating the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. of the PL3 Ecosite.
282. Pedon (Alberta 1979 No. 67) description of an Eluviated Eutric Brunisol of the PL4 Ecosite.
283. Stand (LC9182) illustrating the Engelmann spruce-subalpine fir/heather (O10) portion of the v.t. pattern of the PL4 Ecosite.
284. Pedon (Alberta 1978 No. 63) description of a gleyed Humo-Ferric Podzol of wet depressional segments of the PL5 Ecosite.
285. Stand (PA8170) illustrating the willow/timber oatgrass (S11) v.t. of wet depressional segments of the PL5 Ecosite.
286. General features of the Pipestone (PP) Ecosites.
287. Pedon (Alberta 1975 No. 104) description of a Cumulic Regosol of the PP1 Ecosite.
288. Stand (KS5138) illustrating the lodgepole pine/buffaloberry/twinflower (C19) v.t. of the PP1 Ecosite.
289. Stand (JD9006) illustrating the balsam poplar/buffaloberry (C17) v.t. of the PP2 Ecosite.
290. Pedon (Alberta 1978 No. 92) description of a Cumulic Regosol of the PP3 Ecosite.
291. Stand (JC8085) illustrating the Engelmann spruce-subalpine fir/feathermoss (C13) v.t. of the PP3 Ecosite.
292. Pedon (Alberta 1978 No. 20) description of an Orthic Regosol of the PP4 Ecosite.
293. Stand (IC8093) illustrating the yellow dryad-willowherb (H8) v.t. of the PP4 Ecosite.
294. Pedon (Alberta 1979 No. 85) description of an Orthic Regosol of the PP6 Ecosite.
295. Stand (JD9076) illustrating the Engelmann spruce-subalpine fir/willow/hairy wild rye (O18) v.t. of the PP6 Ecosite.
296. Pedon (Alberta 1979 No. 55) description of an Orthic Humic Regosol of the PP7 Ecosite.
297. Stand (PA9117) illustrating the dwarf birch-willow/kobresia (S9) v.t. of the PP7 Ecosite.
298. General features of the Panorama Ridge (PR) Ecosites.
299. Pedon (Alberta 1979 No. 63) description of an Eluviated Eutric Brunisol of the PR1 Ecosite.
300. Stand (SJ9128) illustrating the lodgepole pine/false azalea/grouseberry (C20) v.t. of the PR1 Ecosite.
301. Pedon (Alberta 1979 No. 43) description of an Eluviated Eutric Brunisol of the PR2 Ecosite.
302. Stand (LC9023) illustrating the lodgepole pine/buffaloberry/twinflower (C19) v.t. of the PR2 Ecosite.
303. Pedon (Alberta 1976 No. 96) description of a Gleyed Brunisolic Gray Luvisol of the PR3 Ecosite.
304. Stand (KS5015) illustrating the lodgepole pine/buffaloberry/grouseberry (C18) v.t. of the PR3 Ecosite.
305. Pedon (Alberta 1978 No. 64) description of an Eluviated Eutric Brunisol from southerly aspect segments of the PR4 Ecosite.
306. Stand (JE8003) illustrating the lodgepole pine/juniper/bearberry (C3) v.t. of southerly aspect segments of the PR4 Ecosite.

307. Pedon (Alberta 1978 No. 67) description of an Eluviated Eutric Brunisol of the PR6 Ecosite.
308. Stand (JE8005) illustrating the lodgepole pine/feathermoss (C11) v.t. of the PR6 Ecosite.
309. General features of the Patricia (PT) Ecosites.
310. Pedon (Alberta 1978 No. 86) description of an Eluviated Eutric Brunisol of the PT1 Ecosite.
311. Stand (AW6037) illustrating the lodgepole pine/buffaloberry/twinflower (C19) v.t. of the PT1 Ecosite.
312. Pedon (Alberta 1979 No. 21) description of an Eluviated Eutric Brunisol, lithic phase, of the PT3 Ecosite.
313. Stand (SJ9124) illustrating the lodgepole pine/juniper/bearberry (C3) v.t. of the PT3 Ecosite.
314. Stand (JE9177) illustrating the aspen/hairy wild rye-peavine (C16) v.t. of the PT4 Ecosite.
315. Stand (LC9179) illustrating the lodgepole pine/feathermoss (C11) v.t. of dry upland segments of the PT5 Ecosite.
316. Stand (LC9178) illustrating the black spruce-lodgepole pine/willow/sedge (C8) v.t. of wet depressional segments of the PT5 Ecosite.
317. General features of the Redoubt 1 (RD1) Ecosite.
318. Pedon (Alberta 1978 No. 54) description of an Orthic Regosol of the RD1 Ecosite.
319. Stand (JC8084) illustrating the heather-everlasting (L5) v.t. of the RD1 Ecosite.
320. General features of the Rocky 1 (RK1) Ecosite.
321. Stand (SJ9019) illustrating the lodgepole pine/buffaloberry/twinflower (C19) v.t. of the RK1 Ecosite.
322. General features of the Sawback (SB) Ecosites.
323. Pedon (Alberta 1978 No. 93) description of a Cumulic Humic Regosol of the SB1 Ecosite.
324. Stand (JC8086) illustrating the aspen/hairy wild rye-showy aster (C22) v.t. of the SB1 Ecosite.
325. Pedon (Alberta 1978 No. 35) description of an Orthic Eutric Brunisol of the SB2 Ecosite.
326. Stand (JE8150) illustrating the Engelmann spruce-subalpine fir/false azalea (C14) v.t. of the SB2 Ecosite.
327. Pedon (Alberta 1979 No. 25) description of an Orthic Eutric Brunisol of the SB3 Ecosite.
328. Stand (PA9132) illustrating the lodgepole pine-buffaloberry/showy aster (C6) v.t. of the SB3 Ecosite.
329. Pedon (Alberta 1978 No. 66) description of an Orthic Eutric Brunisol, lithic phase, of the SB4 Ecosite.
330. Stand (JC8004) illustrating an open variant of the lodgepole pine/juniper/bearberry (C3) v.t. of the SB4 Ecosite.
331. Pedon (Alberta 1979 No. 88) description of an Orthic Eutric Brunisol of the SB5 Ecosite.
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LIST OF PLATES

Frontispiece. Mount Rundle and Vermilion Lakes: an example of the variety of biophysical resources found in Banff and Jasper National Parks.

1. Postglacial residual genetic material on Copper Mountain, Banff.
2. Dip slope failure near Nigel Pass in Jasper; with potential for further failure.
3. Debris cones on a landslide of unconsolidated material; near Dolomite Creek, Banff.
4. An exposure of Ice Contact Stratified Drift B. Note vertical and lateral textural variability, the coarse textures being associated with the gravelly surface and the pocket at the left (under spade), medium textures with the unsorted material. Near Mistaya Canyon bridge, Banff.
5. An abrupt vegetation boundary bordering an active glaciofluvial area at the confluence of Conway, Forbes, and Freshfield Creeks with the Howse River, Banff.
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8. *Pinus contorta/Juniperus communis/Arctostaphylos uva-ursi* (C3) v.t. at 1490 m in southern Banff (JD7114).
9. *Picea glauca/Rosa acicularis/Equisetum arvense* (C4) v.t. at 1000 m in central Jasper (JM8119).
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13. *Pinus contorta/Alnus crispa/Hylocomium splendens* (C10) v.t. at 1420 m on a moderate easterly aspect in central Jasper (IC5072).
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15. *Picea engelmannii-Abies lasiocarpa/Hylocomium splendens* (C13) v.t. in southern Jasper.
16. *Picea engelmannii-Abies lasiocarpa/Menziesia glabella* (C14) v.t. at 1760 m in northern Banff (PA7054).
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21. *Pinus contorta/Shepherdia canadensis/Linnaea borealis* (C19) v.t. at 1480 m in southern Banff (JE8004).
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23. *Picea engelmannii-Abies lasiocarpa/Vaccinium membranaceum/Barbilophozia lycopodioides* (C21) v.t. at 1890 m in northern Banff (JC6112).
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26. *Picea engelmannii-Abies lasiocarpa/Salix vestita/Cassiope tetragona* (C24) v.t. at 2020 m on a steep north aspect in northern Jasper (PA9134).
27. *Picea glauca/Shepherdia canadensis/Thuidium abietinum* (C26) v.t. at 1470 m in northern Banff (PA7059).
28. *Picea glauca/Rosa acicularis/Thuidium abietinum* (C27) v.t. at 1000 m near the east gate of Jasper (JM8001).
29. *Pinus contorta/Ledum groenlandicum* (C29) v.t. at 1590 m in southern Banff (PA7012).
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50. *Betula* spp.-*Potentilla fruticosa-Salix glauca/Tomenthypnum nitens* (S1) v.t. at 1380 m in northern Jasper (PA9011).
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54. *Salix scouleriana-Alnus crispa/Mertensia paniculata* (S6) v.t. at 1380 m in central Jasper (IC5019).
55. *Salix* spp./*Equisetum arvense* (S7) v.t. at 1000 m in central Jasper (SJ8105).
56. *Salix barrattiana/Potentilla diversifolia* (S8) v.t. at 2300 m in northern Banff (PA7133).
57. *Betula glandulosa-Salix glauca/Kobresia myosuroides* (S9) v.t. at 1850 m in southeast Jasper (PA9117).
58. *Salix glauca-Betula glandulosa-Potentilla fruticosa* (S10) v.t. at 2040 m on a steep southwest aspect in central Banff (PA7152.1).
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60. *Salix glauca/Elymus innovatus* (S12) v.t. at 2080 m in northeast Banff (JC8076).
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64. *Phyllodoce glanduliflora-Cassiope mertensiana/Antennaria lanata* (L5) v.t. at 2240 m in western Jasper (SJ7076).
65. *Juniperus horizontalis/Agropyron dasystachyum-Carex scirpoidea* (L6) v.t near Talbot Lake in Jasper.
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67. *Dryas octopetala-Salix nivalis-Silene acaulis* (H1) v.t. at 2340 m in eastern Banff (JD7009).
68. *Carex nigricans-Antennaria lanata* (H2) v.t. in southern Jasper.
69. *Carex scipoidea-Saxifraga aizoides* (H3) v.t. in central Banff.
70. *Dryas octopetala-Kobresia myosuroides-Arctostaphylos uva-ursi* (H4) v.t. at 2330 m in western Jasper (IC6122).
71. *Elymus innovatus-Fragaria virginians-Epilobium angustifolium* (H5) v.t. at 1890 m on a steep southwest aspect in northern Banff (IC7030).
72. *Koeleria cristata-Artemisia frigida-Linum lewisii* (H6) v.t. at 1070 m in central Jasper (IC5003).
73. *Agropyron dasystachyum-Artemisia frigida* (H7) v.t. at 1140 m in central Jasper (IC5018).
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76. *Eriophorum angustifolium/Drepanocladus revolvens* (H10) v.t. at 2320 m in northern Banff (PA8080).
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108. EN2 sample site showing an *Abies lasiocarpa-Salix* spp./*Valeriana sitchensis* (S2) v.t. stand.
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110. FR1 sample site showing a *Pinus contorta/Shepherdia canadensis/Aster conspicuus* (C6) v.t. stand.
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ABSTRACT

Banff and Jasper National Parks occupy about 17,520 km^2 (6765 mi^2) in Canada's southern Rocky Mountains. The area extends from approximately 53° 30' N and 119° 30' W at the northwest corner of Jasper to about 50° 40' N and 115° 20' W at the southern extremity of Banff. It is bounded on the west by the Continental Divide. The Ecological (Biophysical) Land Classification of Banff and Jasper presents landform, soil, and vegetation information in a map and descriptive format at a scale of 1:50,000 using a legend that integrates the three resource components in a holistic fashion. A three-level, hierarchical land classification system was developed using established landform and soil taxonomies, plus a classification of 85 vegetation types developed by the authors. The three levels are based on existing guidelines for Ecological (Biophysical) Land Classification in Canada and include, from highest to lowest level of generalization, Ecoregion, Ecosection, and Ecosite.

Ecoregion separations are based primarily on vegetation physiognomy and species composition which reflect macroclimate. Montane, Subalpine, and Alpine Ecoregions are recognized and mapped at a scale of 1:750,000 in this volume. The Subalpine Ecoregion is subdivided into Lower Subalpine and Upper Subalpine portions based on vegetational characteristics reflecting macroclimatic differences.

The Ecoregions are divided into 55 Ecosections. Ecosection separations are based on broad landform, drainage class, and soil differences. Landforms are comprised of ten genetic materials that have been divided into twenty genetic material units based on broad textural and chemical (calcareousness /reaction) differences.

The Ecosections are further separated into 124 Ecosites based on specific soil and vegetational differences that are considered insufficient, in magnitude or kind, to warrant separation at the Ecosection level. The Ecosites, plus eight Miscellaneous Landscapes, are the mapping units delineated on the twenty-four 1:50,000 maps. The landform, soil, and vegetation of each Ecosite are described in detail in this volume.

PREFACE

As part of a resource inventory of Banff and Jasper National Parks, Parks Canada initiated an Ecological (Biophysical) Land Classification of the two parks in May 1974. The classification includes data pertaining to the characteristics and distribution of landforms, soils, vegetation and wildlife of Banff and Jasper. The results of the classification study are presented in this report.

The report contains generalized and detailed descriptions of the landform, soil, vegetation, and wildlife resources. It has four main components. Volume I is a summary account of landforms, soils, vegetation and wildlife. Volume II provides detailed descriptions of the landforms, soils, and vegetation . Volume III is devoted entirely to wildlife. The fourth part of the report is a Map Supplement, containing 24 maps (scale 1:50,000) of the Ecological (Biophysical) Land Classification information.

The complete report is comprised of the written text of Volumes I, II, and III, plus the maps. To obtain the most complete information, all components should be used as an integral unit. The information in this report is scale dependent so site specific management decisions should be made in consultation with the appropriate specialists. Copies of the annotated air photos used in the field are filed with the Resources Studies Manager in the Western Region Office, Parks Canada, Calgary. In addition, the data are stored in a computer storage bank, CanSIS (Canada Soil Information System), Land Resource Research Institute, Ottawa.

Volume I is a summary overview of the Ecological (Biophysical) Land Classification of Banff and Jasper National Parks, including maps and legends, and is designed to provide a general approximation of the landform, soil, vegetational, and wildlife resources of the parks. Volume II contains a detailed account of the soils and vegetation information collected during the project. The encyclopedic style of Volume II was adopted to allow the readers to consult the report on the subject of immediate interest without necessarily reading it from the front.

Chapter I of Volume II describes the physical environment of Banff and Jasper, starting with climate and its relationship to land. A description of the physiography and topography provides a broad setting in Canada's Southern Rocky Mountains, including information on hydrology. An account of the geology and geomorphology completes the description of the physical setting.

Chapter II reviews previous soils work in the parks and presents field and laboratory methodologies. The soil Orders encountered and their distribution are also outlined.

Chapter III concerns vegetation. The study methodology is described, as are 85 vegetation types (v.t.s), a key to v.t. identification, an overview of community succession, and special and significant species. A checklist of vascular and nonvascular plants is in Appendix A.

Chapter IV provides an ecological integration of the physical and vegetational resources. Here, 55 Ecosections and 124 Ecosites, occurring in three Ecoregions, are described in detail with respect to ecological concept, landform, soils, and vegetational components.

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CHAPTER 1

PHYSICAL ENVIRONMENT

CLIMATE.....W.D. Holland, P.L. Achuff, and B.D. Walker

PHYSIOGRAPHY.....W.D. Holland, G.R. Hillman, and D.T. Allan

GEOLOGY .....W.S. Taylor

GEOMORPHOLOGY.....B.D. Walker, D.T. Allan, and W.S. Taylor

INTRODUCTION

Banff and Jasper National Parks form a crude parallelogram in the southern Rocky Mountains of Canada along the southwestern border of Alberta (Fig. 1). The parks extend southeast for 425 km from approximately 53°30′ N and 119°30′ W at the northwestern corner of Jasper to about 50°40′ N and 115°20' W at the southern extremity of Banff. They are bounded on the west by the Continental Divide and range in width from approximately 106 km to about 10 km. Jasper occupies 10,880 km² (4,200 mi²), while Banff contains 6,640 km² (2,565 mi²).

Chapter 1 describes the physical environment, including climate, physiography, geology, and geomorphology. The climatic section describes temperature, precipitation, and wind variability across the landscape, with particular reference to the three major climatic units (Ecoregions).

The physiography section provides a general setting for the other landscape components, particularly geology and geomorphology, and the ecological mapping units (Ecosites). It also contains a general hydrological description of the area.

The geology and geomorphology sections present information on the stratigraphic and structural frameworks of Banff and Jasper, and how these influence the geomorphic materials. Of particular importance is the relationship between bedrock lithology and the textural and chemical properties of mineral genetic materials.

The geomorphology section deals with landform classification. It identifies four groups of genetic material and, within the unconsolidated mineral group, differentiates ten genetic material classes according to mode of origin. These ten classes are divided into twenty genetic material units (see Landform Classification), named by mode of origin plus an alphabetical symbol, (e.g. Till A, Till B). The twenty units are differentiated by textural and chemical properties as outlined in the geology section. However, the geomorphology section provides the greatest detail on textural and chemical properties of the genetic material units and includes a discussion of their formation, modifying processes, and relationships to other landscape components. These genetic material units frequently differentiate mapping units in the Ecological Land Clasification legend, particularly at the Ecosection level.

CLIMATE

W.D. Holland, P.L. Achuff, and B.D. Walker

OVERVIEW

Climatic data for Banff and Jasper National Parks are scarce, especially for the Upper Subalpine and Alpine Ecoregions. Chapman (1952), Trewartha (1957), Bailey (1962), and Janz and Storr (1977) provide climatic overviews of the Canadian Rocky Mountains. In particular, Janz and Storr (1977) give the most detailed and recent analysis of climate for the contiguous mountain parks. Other sources such as the *Atlas of Alberta* (Govt. of Alberta and Univ. of Alberta 1969) and the *National Atlas of Canada* (Surveys and Mapping Branch 1972) point out the insufficiency of data and in some instances indicate erroneous information (e.g. the extent of permafrost).

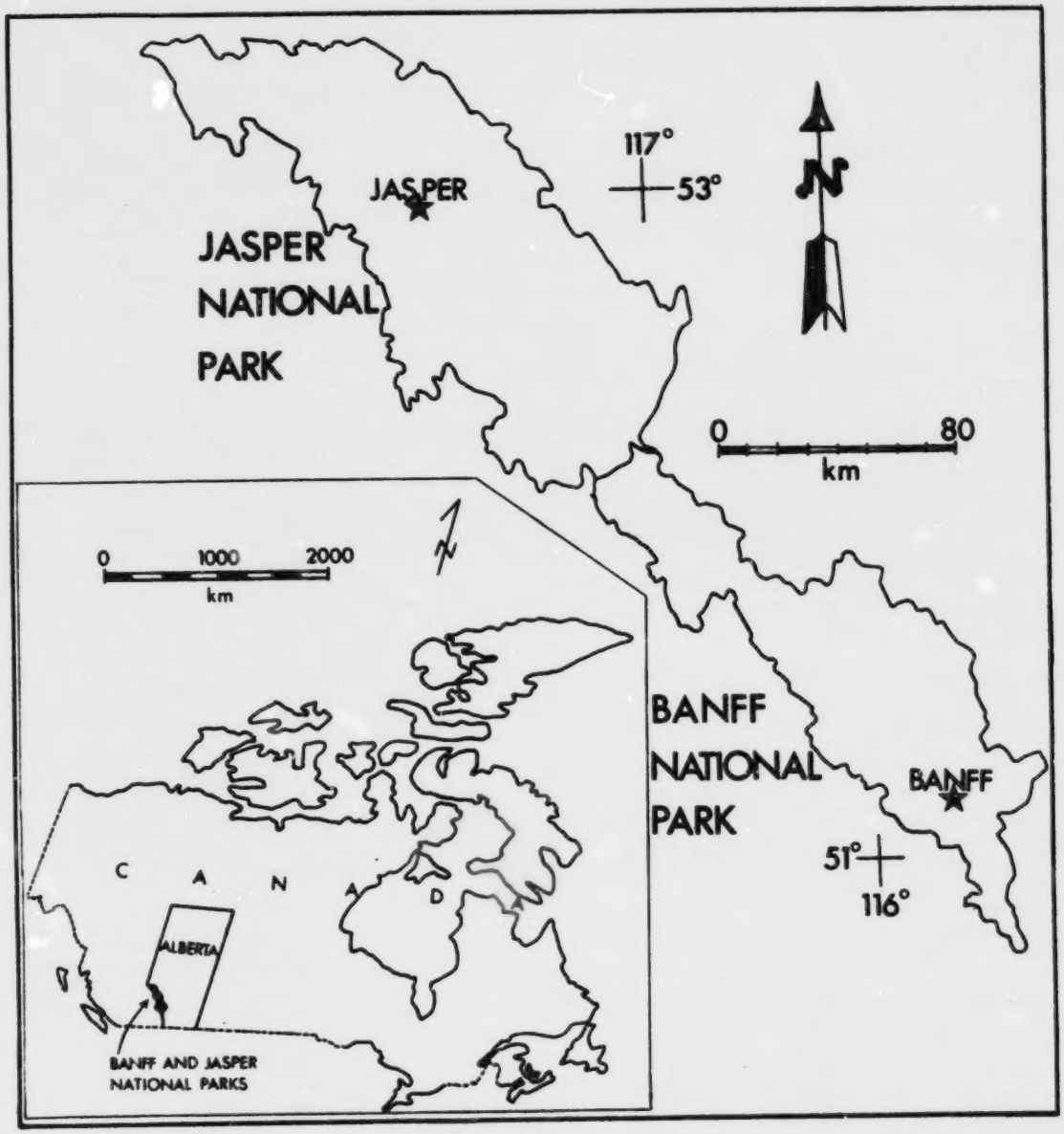


Figure 1 Location of study area.

Chapman (1952) and Heusser (1956) indicate that the Rocky Mountains inhibit westward movement of Polar Continental air but that cold air from the Yukon and Alaska easily moves parallel to the northwest-southeast trend of major valleys. Bailey (1962) criticizes Koeppen's climatic types because of limitations of map scale. Nevertheless, according to Koeppen's climate classification (Trewartha 1957) most of the valley bottoms and lower slopes of Banff and Jasper have a Dfc climate (Cold Snowy Forest Climate with no distinct dry season; cool short summers).

JANZ AND STORR'S STUDY (1977) ABSTRACTED

Location and Climate

The general climate of Banff and Jasper is determined chiefly by geographic location and topography. Geographic position considers latitude, proximity to oceans, and intervening mountain barriers. Latitude, ranging from 50°45' N to 53°30' N, determines the amount and distribution of solar energy plus

the nature and intensity of high and low pressure systems that migrate across the parks. The continental macroclimate of Banff and Jasper is a function of their position in the North American continent. They are located near the prairies, a considerable distance from the Pacific Ocean. Several major, intervening mountain ranges intercept some of the moisture carried by westerly winds. The absence of a major range to the east permits moisture from Hudson Bay, the Arctic Ocean and the Gulf of Mexico to reach the region.

Continental climate implies greater variability in seasonal and annual precipitation and temperature patterns than occurs in a maritime climate. In general, Banff and Jasper have long winters which can be cold, and short summers which are cool with occasional hot spells. Both parks are subject to the same air masses and weather systems that migrate across western Canada at mid-latitudes. The mountain topograhy, however, modifies and macroclimate creating mesoclimatic and microclimatic gradients. The mesoclimates are related to topography and several physiographic features of special importance.

Orientation of Mountain Ranges

The northwest-southeast orientation of the mountains and main valleys is almost at right angles to the prevailing winds aloft giving a rain shadow effect in main valleys. The generally low wind speeds in the valleys are also related to this orientation. However, wind speeds are higher where valleys, or portions of them, cut across the main northwest-southeast mountain ranges and in large valleys such as the lower Athabasca and Bow River valleys.

The Front Ranges and Foothills just east of Banff and Jasper block cold Arctic air from entering the parks. Arctic air plunging southward across the Alberta plains usually must enter Banff and Jasper through minor openings in the Front Ranges. Thus, outbreaks of cold are usually not as severe or as prolonged as on the prairies to the east. However, major valleys, such as the eastern portion of the Bow River valley, provide significant openings to the prairies and permit the intrusion of Arctic air. The Front Ranges are also effective in blocking "upslope" precipitation from reaching the interior of the parks.

Topography and Elevation

Topography and elevation influence the climate of Banff and Jasper by causing climatic variation over short distances. Variations in climate can occur with elevation changes of less than 100 m. Of particular importance is aspect. Significant vegetation and, in some areas, soil differences are related to northerly (northwest to east) versus southerly (southeast to west) aspect.

CLIMATE AND ECOREGIONS

Climatic elements such as solar radiation, wind, and precipitation provide the energy which is the basic driving force for ecosystems. Ecosystems consist of both biotic and physical components which interact to produce the landscape features of the parks. Climate, as part of the physical component, is influential in determining characteristics of other ecosystem components. Differences in climatic factors produce different ecosystems and ecosystem components. Lack of sufficient climatic data makes it impossible to classify Banff and Jasper, at scales of 1:250,000 and larger, using climatic data solely. Thus, vegetation has been used to indicate climatic units, since vegetation, as a biotic component of an ecosystem, strongly reflects climate. Many other factors besides climate influence vegetation. However, by dealing with vegetation at a high level of generalization, these other factors (slope, aspect, soil texture, fire, etc.) are less significant and the vegetation reflects mainly climate. Based primarily on vegetation physiognomy and composition, four units have been delineated: Montane Ecoregion, Subalpine Ecoregion (with Lower Subalpine and Upper Subalpine portions), and Alpine Ecoregion. An approximation of their distribution is shown in the section on Ecoregions, Chapter III. The following describes the climate of the units; for further descriptions of their vegetational definition and soil, landform and wildlife characteristics see appropriate portions of this report.

The most complete climatic data are available for the Montane, which is the smallest of the Ecoregions. Table 1 compares temperature and precipitation data of Banff and Jasper townsites, both located in the Montane, and Village Lake Louise, located in the Lower Subalpine. Even though Jasper townsite is farthest north of the three stations, it is considerably lower in elevation, hence the warmer temperature and lower precipitation, particularly snowfall. Fig. 2 is a graphic illustration of the same data and Fig. 3 depicts climate for Banff townsite, Village Lake Louise, and Jasper townsite according to Koeppen's (Trewartha 1957) classification system. Tables 2 and 3 show variation in annual precipitation at stations recently established in Jasper and Banff. Table 4 compares short and long term data.

THE MONTANE ECOREGION

The climate of the Montane Ecoregion (Tables 2 and 3) is the warmest and driest in the two parks. Based on the Banff and Jasper townsite data (Table 1), the mean

Table 1 Mean monthly temperature and precipitation at Banff and Jasper Townsites and Village Lake Louise.

BANFF: 51° 11' N, 115° 34' W elevation 1397 m				**LAKE LOUISE:** 51° 25' N, 116° 10' W elevation 1534 m				**JASPER:** 52° 53' N, 118° 04' W elevation 1061 m			
Month	**Mean daily temperature °C**	**Mean precipitation mm**	**Snowfall cm**	**Month**	**Mean daily temperature °C**	**Mean precipitation mm**	**Snowfall cm**	**Month**	**Mean daily temperature °C**	**Mean precipitation mm**	**Snowfall cm**
Jan.	-10.6	33	30.5	Jan.	-14.4	81	81	Jan.	-10.6	28	25
Feb.	- 7.8	30	27.9	Feb.	-11.1	66	66	Feb.	- 7.2	25	23
Mar.	- 3.9	25	22.9	Mar.	- 6.1	51	51	Mar.	- 3.3	15	13
Apr.	2.2	36	25.4	Apr.	0.6	53	46	Apr.	3.3	20	8
May	7.8	46	5.1	May	6.1	51	15	May	8.9	36	3
June	10.6	64	trace	June	9.4	64	3	June	12.2	56	0
July	14.4	43	0	July	12.8	51	0	July	15.0	51	0
Aug.	13.3	51	0	Aug.	11.1	58	0	Aug.	13.9	56	0
Sept.	8.9	36	5.1	Sept.	7.2	51	5	Sept.	10.0	36	trace
Oct.	3.9	41	20.3	Oct.	2.2	66	43	Oct.	5.0	28	3
Nov.	- 3.9	33	25.4	Nov.	- 6.7	84	81	Nov.	- 3.3	30	20
Dec.	- 8.3	38	35.6	Dec.	-11.7	107	104	Dec.	- 7.3	33	28
Mean Yearly	2.2	476	198.2	Mean Yearly	0	783	495	Mean Yearly	3.0	414	123
No. of years	29	29		No. of years	30	30		No. of years	25	25	
42% of precipitation as snow				63% of precipitation as snow				29% of precipitation as snow			

Table 2 Average annual precipitation, October 1966 to September 1980, for stations in Jasper National Park.

Station	Type of Gauge [a]	Elevation (m)	Latitude	Longitude	No. Years Observation	Precipitation Avg./Yr. (mm)	Ecoregion
Jasper East Gate	1	1003	53° 14′	117° 49′	14	619	Montane
Warden Station (U. of A.)	2	1024	52° 48′	118° 08′	6	361	
Jasper (townsite)	1	1061	52° 53′	118° 04′	14	383	
Jasper West Gate	1	1127	52° 52′	118° 23′	5	571	
Athabasca Falls	1	1181	52° 40′	117° 53′	6	421	
						$\bar{X}$=471	
Miette Hot Springs	1	1341	53° 08′	117° 46′	6	827	Lower Subalpine
	2	1341	53° 08′	117° 46′	10	684	
Willow Creek	2	1402	53° 23′	118° 21′	8	422	
Smoky River Warden	2	1463	53° 22′	119° 16′	9	701	
Sunwapta Warden	1,2	1554	52° 27′	117° 27′	9	797	
Signal 4	2	1677	52° 53′	117° 59′	6	586	
Pyramid 4	2	1677	52° 58′	118° 07′	6	801	
Athabasca Pass	2	1745	52° 23′	118° 11′	4	1561*	
Topaz Lake	2	1758	53° 23′	118° 48′	8	524	
Brazeau Warden	2	1768	52° 24′	117° 01′	9	438	
Rocky Forks	2	1840	52° 50′	117° 24′	8	622	
Maligne Lake	2	1845	52° 44′	117° 38′	10	565	
						$\bar{X}$=710.7	
		*Excluding Athabasca Pass station $\bar{X}$ = 633.4					
Amethyst Lake	2	1966	52° 42′	118° 16′	8	974	Upper Subalpine
Columbia Icefields	1	1981	52° 41′	117° 10′	7	792	
Marmot Basin	2	1982	52° 47′	118° 07′	10	742	
Pyramid 5	2	2043	52° 58′	118° 07′	6	713	
Signal 2	2	2043	52° 52′	117° 59′	6	691	
						$\bar{X}$=782.4	
Pyramid Mountain	2	2767	52° 57′	118° 08′	10	595	Alpine

a Type of Gauge:

1 Daily
2 Sacramento Storage Gauge (usually recorded twice a year)

Table 3 Average annual precipitation, October 1966 to September 1980, for stations in Banff National Park.

Station	Type of Gauge a	Elevation (m)	Latitude	Longitude	No. Years Observation	Precipitation Avg./Yr. (mm)	Ecoregion
Banff	1	1397	51° 11′	115° 34′	14 $\bar{X}$=	455 455	Montane
Howse R. Cabin	2	1494	52° 03′	116° 47′	10	492	Lower Subalpine
Alexandra R. Cabin	2	1494	52° 03′	117° 07′	10	582	
Lake Louise	1	1533	51° 25′	116° 10′	14	569	
Brewster Ck. (headwaters)	2	1575	51° 08′	115° 41′	9	747	
Cascade Lem	2	1646	51° 20′	115° 35′	6	490	
Waterfowl Lake	2	1793	51° 51′	116° 38′	10	711	
Sarbach L.O.	2	1829	51° 55′	116° 45′	13	719	
Temple Lodge	2	1890	51° 26′	116° 09′	14 $\bar{X}$=	667 662	
Bow Summit	2	2070	51° 43′	116° 27′	14	728	Upper Subalpine
Alexandra L.O.	2	2043	52° 06′	116° 55′	10	773	
Fatigue	2	2143	51° 01′	115° 40′	9	875	
Snowflake I.J.P.	2	2210	51° 38′	115° 50′	6	523	
Sunwapta (Nigel Ck.)	2	2256	52° 12′	117° 07′	14 $\bar{X}$=	814 742.6	

a Type of Gauge

1 Daily
2 Sacramento Storage Gauge (usually recorded twice a year)

Table 4 Comparison of short term (October 1966 - September 1980) with long term (1941 - 1970, Environment Canada, 1975) precipitation data at Banff and Jasper townsites and Village Lake Louise.

	Annual Precipitation (mm)	
Station	Oct. 1966 - Sept. 1980	1941 - 1970
Banff townsite	455	477
Jasper townsite	383	402
Village Lake Louise	569	767

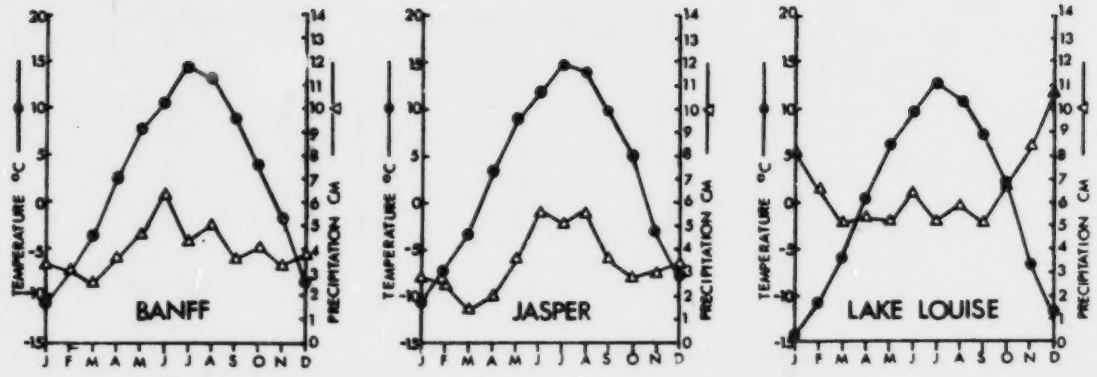


Figure 2 Mean monthly temperature and precipitation for Banff and Jasper townsites and Village Lake Louise.

Banff Dfb - Cold Snowy Forest Climate with no distinct dry season; cool summer.
Jasper Dfb - Cold Snowy Forest Climate with no distinct dry season; cool summer.
L. Louise Dfc - Cold Snowy Forest Climate with no distinct dry season; cool, short summer.

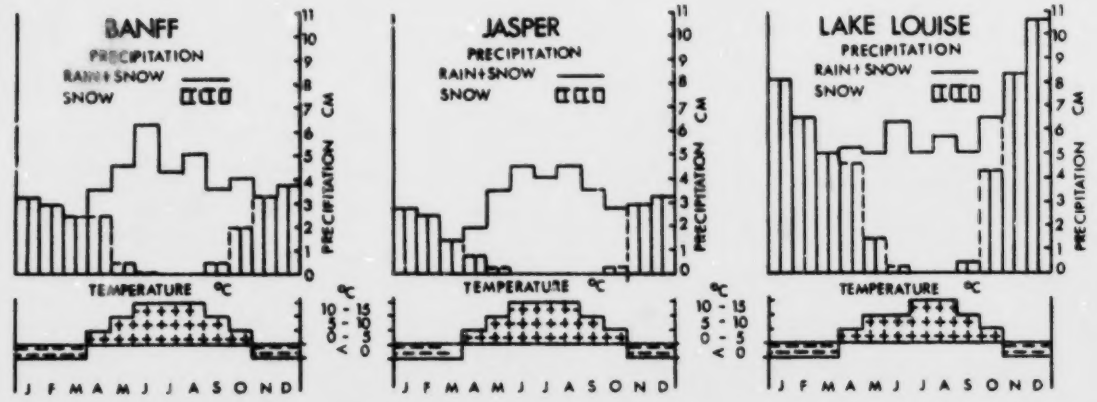


Figure 3 Classification of Banff and Jasper townsites and Village Lake Louise climates according to Koppen (1936).

D - Cold Snowy Forest Climates. Average temperature of coldest month less than -3° C (26.6° F); average temperature of warmest month more than 10° C (50° F).
f - No distinct dry season - driest month of summer more than 3 cm (1.2 inches).
b - Cool summer - average temperature of warmest month less than 22° C (71.6° F).
c - Cool, short summer - less than four months with more than 10° C (50° F).

yearly temperature is 2° to 3°C. Warm winter winds (chinooks) from Pacific air masses raise winter temperatures and the Montane Ecoregion is intermittently snow-free. In the months of December to February, Banff and Jasper townsites have about 25 days with temperatures above freezing (Janz and Storr 1977). The mean January daily temperature for Banff and Jasper townsites is approximately 4°C warmer than at Village Lake Louise, representing the Lower Subalpine (Table 1). Summer temperatures are slightly higher in the Montane than the Lower Subalpine (1.6 - 2.2°C warmer for Banff and Jasper townsites versus Village Lake Louise, Table 1). However, temperature fluctuation is probably greatest in the Montane. In the winter, temperature inversions occur when light winds permit little mixing and when cold Arctic air invades from the north. Under these conditions, the Montane Ecoregion may be colder than the adjacent Subalpine Ecoregion. Consequently, extreme minimum temperatures in the range of -50 to -54°C have been experienced in the main valleys below 1500 m elevation (Janz and Storr 1977). Extreme maxima are of the order of 38°C in valleys below 1200 m but tempera-

tures above 32°C are relatively rare (Janz and Storr 1977). These authors also point out that maximum temperatures at Banff and Jasper townsites exceed 21°C on 1 day out of 2 in July and August. Another indicator of the mild Montane climate is frequency of frost. For example, Banff townsite averages 4 days with frost for the period of June through August. In the Mount Eisenhower to Lake Louise section of the Bow River valley, this increases to 24 to 27 days for the same period (Janz and Storr 1977).

Average annual precipitation for the Montane is about 465 mm (Tables 2 and 4). Summer precipitation is slightly greater than winter precipitation (Figs 2 and 3) and the incidence of measurable summer snowfall is very low. Snowfall during the autumn is also low in some years.

Few wind records are available. As mentioned previously, the orientation of valleys contributes to wind speed and direction. Much of the Montane occurs in large valleys (the lower Athabasca, North Saskatchewan, and Bow River valleys) that are oriented approximately east-west, where they traverse the northwest-southeast trending mountain ranges. Winds in these areas are slightly stronger and more frequent than in other areas of the parks because the valleys are oriented approximately parallel to the prevailing westerlies aloft. Presently aggrading eolian deposits in the lower Athabasca and North Saskatchewan River valleys attest to this phenomenon.

THE SUBALPINE ECOREGION

The Subalpine Ecoregion occurs at elevations above the Montane Ecoregion and is cooler and moister. The mean yearly temperature is about 0°C at low elevations, based on the Village Lake Louise data (Table 1), and decreases with increasing elevation (i.e. about 0.5°C/100 m summer lapse rate). The mean annual temperature at our weather station on Mt. White, located on a north aspect in the Upper Subalpine in eastern Banff, is -1°C, based on 2½ years of data. Winter chinooks are not common in the Subalpine and snow cover is therefore continuous during winter. Janz and Storr (1977) suggest that higher elevation areas rarely have temperatures above freezing in the months of December to February. Temperature fluctuation is narrower in the Subalpine compared to the Montane. Janz and Storr (1977) indicate that although all parts of Banff and Jasper likely have had temperatures of -40°C, the occurrence of extreme minima in the -48 to -54°C range above 1500 m elevation is rare. The extreme minimum temperature at the Mt. White site, from 3 winters of data, was -37°C. Winter temperature inversions also occur in the Subalpine with valley bottoms often being colder than adjacent slopes. This sometimes produces non-forested frost hollow vegetation in valley bottoms with forests on adjacent slopes. "Red-belt", desiccation injury of coniferous trees, occurs mainly in the Subalpine Ecoregion when warm Pacific air overruns colder air. Extreme maximum temperatures are lower than in the Montane because of a decrease with elevation that is probably similar to the lapse rate of mean maximum temperature (i.e. about 0.7 - 0.8°C/100 m, Janz and Storr 1977). Data from Bow Pass (6 years record, Janz and Storr 1977) and Mt. White (2 1/2 years record) indicate extreme maximum temperatures of 28 to 29°C in the Upper Subalpine at 1850 to 1970 m elevation.

Precipitation increases with elevation and the average annual precipitation of the Upper Subalpine (763 mm) is greater than the Lower Subalpine (665 mm), based on data from a few stations (Tables 2 and 3). Winter precipitation is greater than summer precipitation (Figs. 2 and 3) and the incidence of measurable summer snowfall is greater than in the Montane. Precipitation in eastern portions of the parks appears to be lower than in western regions, based on a comparison of data from eastern (Miette Hot Springs, Willow Creek, Brazeau Warden, Rocky Forks, Cascade Lem, and Snowflake I.J.P.) versus western stations located in the Subalpine (Tables 2 and 3). This trend is supported by the extensive occurrence of dry grassland and shrubland vegetation and Cryosolic soils in eastern Subalpine regions (Achuff and Coen 1980). Conversely, Janz and Storr (1977) describe the area from Athabasca Pass to Freshfield Icefield (the Icefields area) as having an abnormally high precipitation regime relative to other areas of the parks. Snowfall, in particular, is very high. Janz and Storr (1977) suggest two factors contribute to this phenomenon. First, the Icefields area has a higher average elevation than any other area of similar size in Banff and Jasper. Secondly, a gap in the Selkirks formed by the big bend of the Columbia River lies almost due west of the Icefields area and allows passage of moist Pacific air.

Wind records for the Subalpine are scarce. Winds are generally light, although there is evidence of wide variation, related mostly to topography. Forest blowdown occurs locally and is most common in the east-west trending valleys that traverse the mountain ranges (e.g. the Snake Indian River valley between Mt. Kelsey and Willow Creek). Winds at higher elevations are stronger and more frequent as indicated by stunted and krummholz open forest occurring at the upper elevational limits of the Subalpine. The greatest effects are on exposed localities where forest may be absent. Winter observations also suggest that redistribution of snow by wind is important for the maintenance of grassland vegetation in eastern portions of the parks.

THE ALPINE ECOREGION

The Alpine Ecoregion occurs at elevations above the Subalpine Ecoregion and is the coldest in Banff and Jasper. Climatic data for Alpine areas are very few but cool mean temperatures are projected based on the trends demonstrated by a comparison of temperatures between the Montane and Subalpine Ecoregions. Additionally, the lack of forest vegetation demonstrates the rigorous climate, a significant part of which is temperature. Janz and Storr (1977) present temperature profiles based on data from various stations in Banff and Jasper and Marmot Creek basin located to the southeast of Banff. These show that as mean temperature decreases with increasing elevation, temperature range (the difference between maximum and minimum) also decreases. This trend also extends to extreme maxima and minima.

Due to the lack of climatic data, precipitation totals are uncertain. Precipitation increases with altitude from the Montane Ecoregion upward into the Alpine Ecoregion. However, somewhere in the Alpine the trend may reverse. Thus, it is difficult to generalize about Alpine precipitation. It is anticipated that trends of lower precipitation in eastern regions of the parks and heavy precipitation in the Icefields area discussed for the Subalpine Ecoregion also apply to the Alpine.

It is generally accepted that wind speed increases with elevation but there are virtually no data to quantify the relationship. Additionally, topographical influences on wind speed are greater than elevational influences. Nevertheless, Janz and Storr (1977) report that all areas above about 2300 m elevation are windy but that winds may be light in high elevation areas for several days in succession, particularly in summer. Winds are important in the Alpine. Erodible, exposed surfaces are often deflated and snow is redistributed by wind. Complex vegetation patterns in the Alpine are often linked to varying topographic exposures and resultant snow depth variability.

CLIMATIC DATA SOURCES

The following discussion gives general information on the kind and quality of climatic data available from Banff and Jasper National Parks. Data from several of these stations are presented in Tables 1, 2, 3, and 4.

FIRST ORDER STATIONS

Banff townsite records date back to 1887. The earliest records are of temperature and precipitation; later data include hourly observations of wind and sunshine. The data are representative of only the immediate area around the town. For Jasper townsite, the first order stations provide hourly observations of temperature, wind, precipitation, and humidity.

CLIMATIC STATIONS

These sources provide maximum and minimum temperatures and daily precipitation. Banff stations include Lake Louise since 1915, Anthracite from 1929-1962, and Mount Eisenhower from 1960-1971.

WARDEN STATIONS

In Banff, only a few wardens' records of any length can be located. Ski resorts such as Sunshine and Temple in Banff have some observations reported by the Warden Service. In Jasper, they are mainly temperature records, generally from thermograph charts.

STORAGE GAUGES

These data report seasonal precipitation only, as recorded by Sacramento or Fisher Porter gauges.

RESEARCH STATIONS

These data are often short term records of the elements in which a researcher is interested. Because the observations are recorded mainly during the summer and are of short duration, it is difficult to make meaningful correlations with more permanent stations. The most valuable research records are those taken by the Canadian Forestry Service and the Glaciology Division of the Geological Survey of Canada.

PHYSIOGRAPHY

W.D. Holland, G.R. Hillman, and D.T. Allan

INTRODUCTION

Banff and Jasper National Parks are situated within the Continental Ranges of the Southern Rocky Mountains which are part of the Eastern System of the Cordilleran Region of Canada (Bostock 1970). The Front and Main Ranges (Fig. 4) form the geologic subprovinces that provide structural control of the physiographic features. The mountain system is composed almost entirely of thrust faulted and occasionally folded sediments (Price and Mountjoy 1970a).

A most conspicuous feature of the Front Ranges is the linear northwest-southeast direction of the ranges and the parallel valleys that separate them. The dip of the bedrock is usually toward the southwest, thus providing long smooth slopes on this aspect. The northeast aspects are often precipitous, with broken faces and cliffs. These features are demonstrated by the photograph of Mount Rundle on the frontispiece. The Main Ranges strata, for the most part gently dipping, produce nonlinear ranges with high indi-

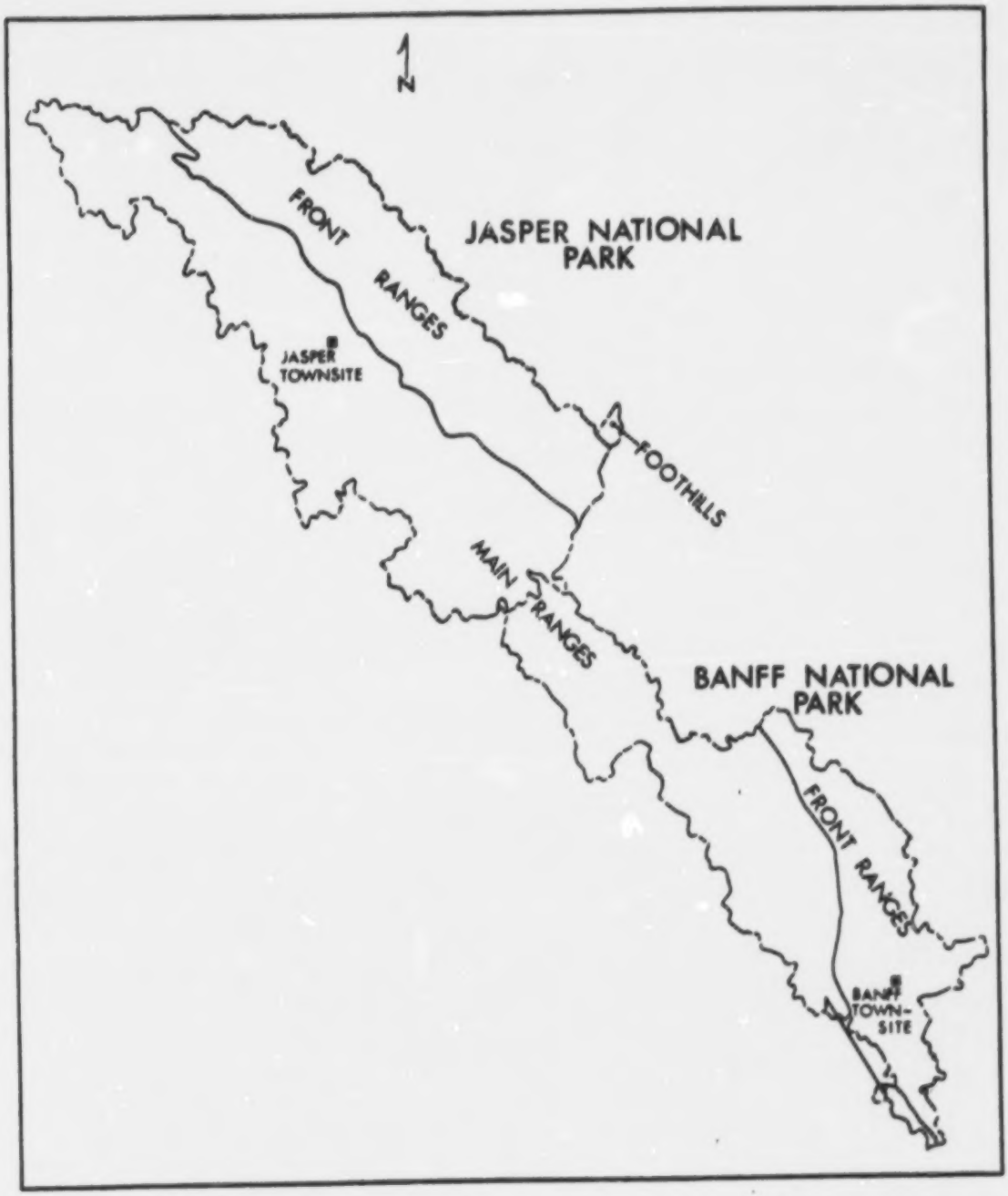


Figure 4 Geologic subprovinces of Banff and Jasper.

vidual or clustered peaks capped by resistant rock, and typify the majestic scenery for which the parks are perhaps most famous.

Elevations of the mountain tops generally increase from east to west, from a low of 2117 to 3100 m in the Front Ranges to heights of 3000 to just over 3300 m in the Main Ranges. The highest elevations occur around the Columbia Icefield, reaching from 3400 to just over 3700 m. The valley bottoms also have high elevations, the lowest being at 990 m in Jasper near Brule Lake and 1330 m where the Bow River leaves Banff. The main valley bottoms commonly have elevations between 1200 and 1500 m. The effect of high elevation on precipitation, temperature, and topography result in the parks being a

headwaters area for some of Canada's larger rivers. The main valleys of the Bow, Athabasca and North Saskatchewan rivers are the largest in the parks and, though they are to some extent parallel to the northwest-southeast direction of the mountain ranges, they do eventually cut across the ranges allowing drainage flow onto the Alberta plains to the east and north. A number of smaller rivers are also transverse to the mountain ranges, namely the Panther, Red Deer, and Clearwater Rivers in Banff, and the Brazeau, Southesk, and Smoky in Jasper. Otherwise, the rivers and their tributaries exhibit a definite trellis drainage pattern.

DRAINAGE AND HYDROLOGY

Banff and Jasper National Parks play an important role in supplying water to residents and tourists in the parks and, more particularly, to downstream users. Total annual runoff from the area ranges from about 380 mm near the eastern boundaries to over 1000 mm near the Continental Divide (Neill et al. 1970). This compares with minimum mean annual precipitation of about 380 to 500 mm in the main river valleys, and maximum of over 1250 mm near the Divide (Janz and Storr 1977). Reports for adjacent mountainous areas east and south of the Parks indicate that mean annual runoff may exceed 60% of mean annual precipitation, but for many streams the average annual water yield is between 40 and 50% of mean annual precipitation (Eastern Rockies Forest Conservation Board 1963-71, Hanson n.d.).

The rivers that issue from Banff and Jasper are fed by the extensive ice and snow-fields that persist year-round at high elevations. Records for several hydrometric stations maintained within and adjacent to the parks (Water Survey of Canada 1910-1979, Water Survey of Canada 1980) are widely used in flood frequency analyses and to describe streamflow characteristics (Neill et al. 1970, Kellerhals et al. 1972, Stolte and Dumontier 1977, F.F. Slaney and Company Limited 1978, Golder Associates 1981). They indicate that about 70% of the total annual flow occurs during the months June through August. Peak discharges are usually reached in June or July (Fig. 5).

Stream courses are strongly controlled by topography. In Banff and Jasper they may be characterized by some or all of the following features: steep gradients, waterfalls, rapids, gorges, canyon walls, and coarse bed materials. Rivers, such as the Chaba, Sunwapta, and the upper headwaters of the Athabasca, which flow through flat-bottomed valleys, deposit glaciofluvial materials on the valley floor. This deposition has produced extensive braided stream systems in these valleys.

Stream gradients reported in the literature (Kellerhals et al. 1972, Donald et al. 1977, F.F. Slaney and Company Limited 1978, and Golder Associates 1981) reflect the position of the stream channel reach relative to the main valley floor. Mountain Creek (gradient: 80 m/km) and Sulphur Creek (71 m/km), for example, drain steep mountain terrain and flow into larger streams with gentler gradients. Sulphur Creek joins the Fiddle River which has an average gradient of 17 m/km. Gradients of 19 and 15 m/km have been reported for Forty Mile Creek and the Pipestone River near Lake Louise, respectively. In contrast, the Bow River which flows through a main valley, has a gradient of 0.13 m/km at Banff. The gradient of the Athabasca River at Jasper is 3 m/km.

Banff National Park is drained entirely by the Saskatchewan River system (Fig. 6), the primary source of water for the Great Plains region of Alberta and Saskatchewan. Although mountains comprise only ⅛ of the total drainage area, Banff, Jasper, and Waterton Lakes National Parks and the adjacent Rocky Mountains Forest Reserve supply ⅓ of the total annual flow of the Saskatchewan River system (Hanson n.d.) From northern Banff, the North Saskatchewan River is fed by the Alexandra, Howse, Mistaya, Siffleur, and Clearwater Rivers. Other large rivers such as the Red Deer, Panther, Bow, Pipestone, and Cascade are part of the South Saskatchewan River system.

Jasper National Park is drained primarily by the Athabasca River system. The major rivers tributary to the Athabasca River within the park include the Snake Indian, Snaring, Miette, Rocky, Chaba, Sunwapta, Maligne, and Whirlpool Rivers. The Brazeau River forms the southeast boundary of the park and drains into the North Saskatchewan River. The northwestern portion of the park is drained by the Smoky River which is part of the Peace River system (Fig. 6).

A recent floodplain study of the Bow River at Banff townsite (Beckstead 1980) indicated that the 100-year flood (40b m^3/s) will cause major flooding in the recreation grounds south of the Bow River and upstream from the Banff Avenue Bridge. Flooding has been reported on 11 occasions since 1894. In each case maximum daily discharge exceeded 283 m^3/s (1000 ft^3/s). The record maximum daily discharge (377 m^3/s) occurred 15 June, 1923. Floods of this magnitude are usually accompanied by road and rail track washouts and the destruction of bridges on tributary streams such as the Spray River. The estimated 100-year flood for many stations in Banff and Jasper National Parks, and in the adjacent areas of Alberta are given in Stolte and Dumontier (1977) and in Golder Associates (1981).

Jasper townsite is situated high enough above

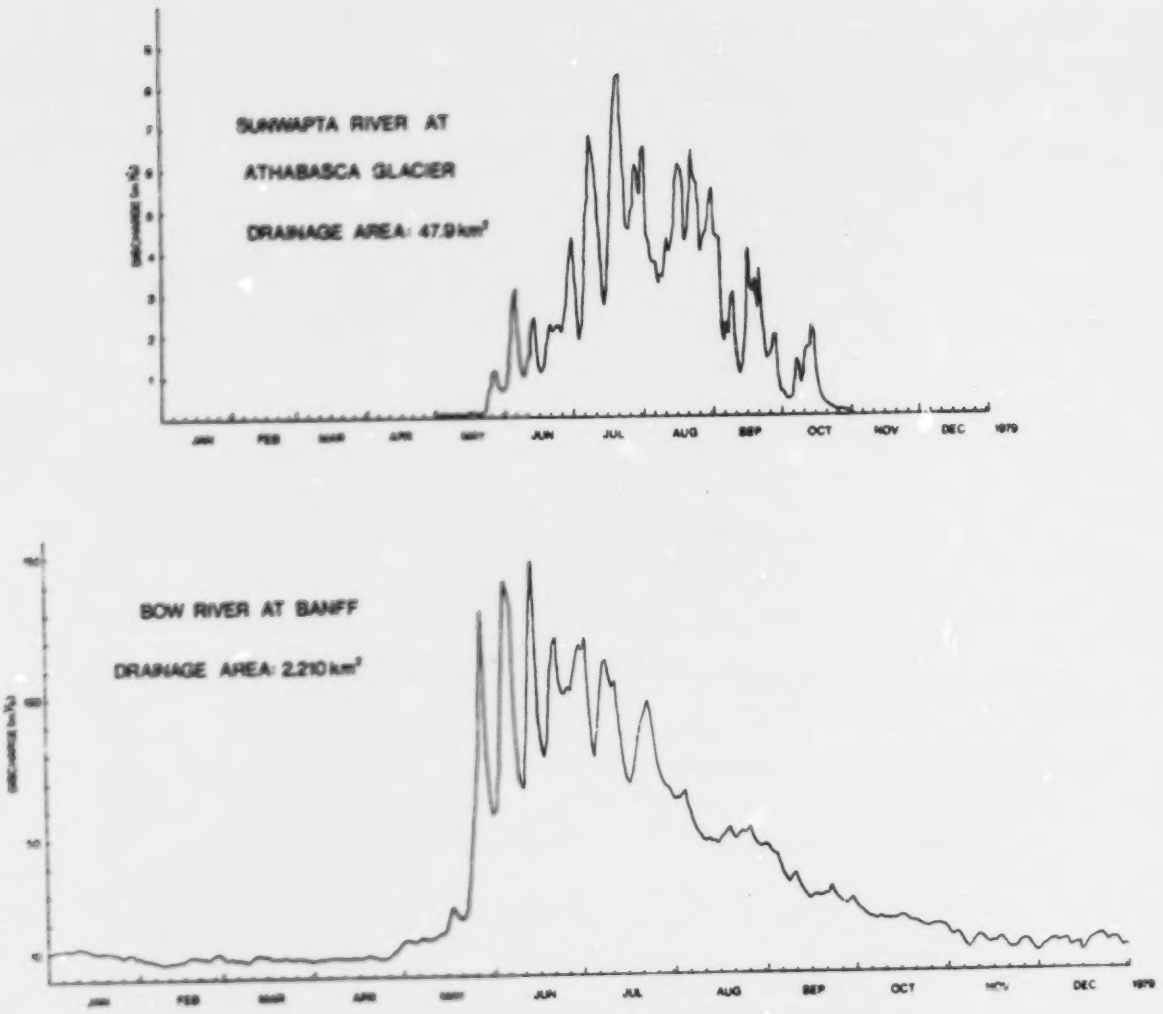


Figure 5 Hydrographs showing dominance of summer flows for streams in Banff and Jasper National Parks. (from data supplied by the Water Survey of Canada).

the Athabasca River that there is less risk of the town being flooded by the river than by upslope runoff from intense rainstorms. During extreme flood conditions the Athabasca River will extend into the low-lying areas in the vicinity of Beauvert Lake and Mildred Lake.

Intense 24-hour rainstorms in excess of 50 mm, and of the 'cold low' type have been recorded at Jasper townsite on three occasions: August 5, 1969 (108 mm), July 1, 1935 (86 mm), and May 22, 1944 (70 mm) (Janz and Storr 1977). The storm of August 5, 1969 caused extensive rock slides along the highway between the townsite and the east gate of the park. Railroad tracks were washed out and streams in the Jasper area became torrents (Janz and Storr 1977).

A 'cold low' was also responsible for the spectacular once in hundred years flood on the Smoky River drainage in June 1972 (Warner and Thompson 1974). The Alberta Resource Railway together with the towns of Grande Prairie, Grande Cache, and Peace River were all affected by the flood. Together they sustained losses in excess of $8 million. Although the Smoky River rises in Jasper National Park, the centre of the storm (200 mm isohyet) was located at Nose Mountain, well to the north of Jasper. Precipitation for the same storm in Jasper was about 50 to 75 mm.

The hydroelectric power potential of the Bow River drainage was investigated early in Banff's history (Hendry 1914). Development of the Cascade River for power production

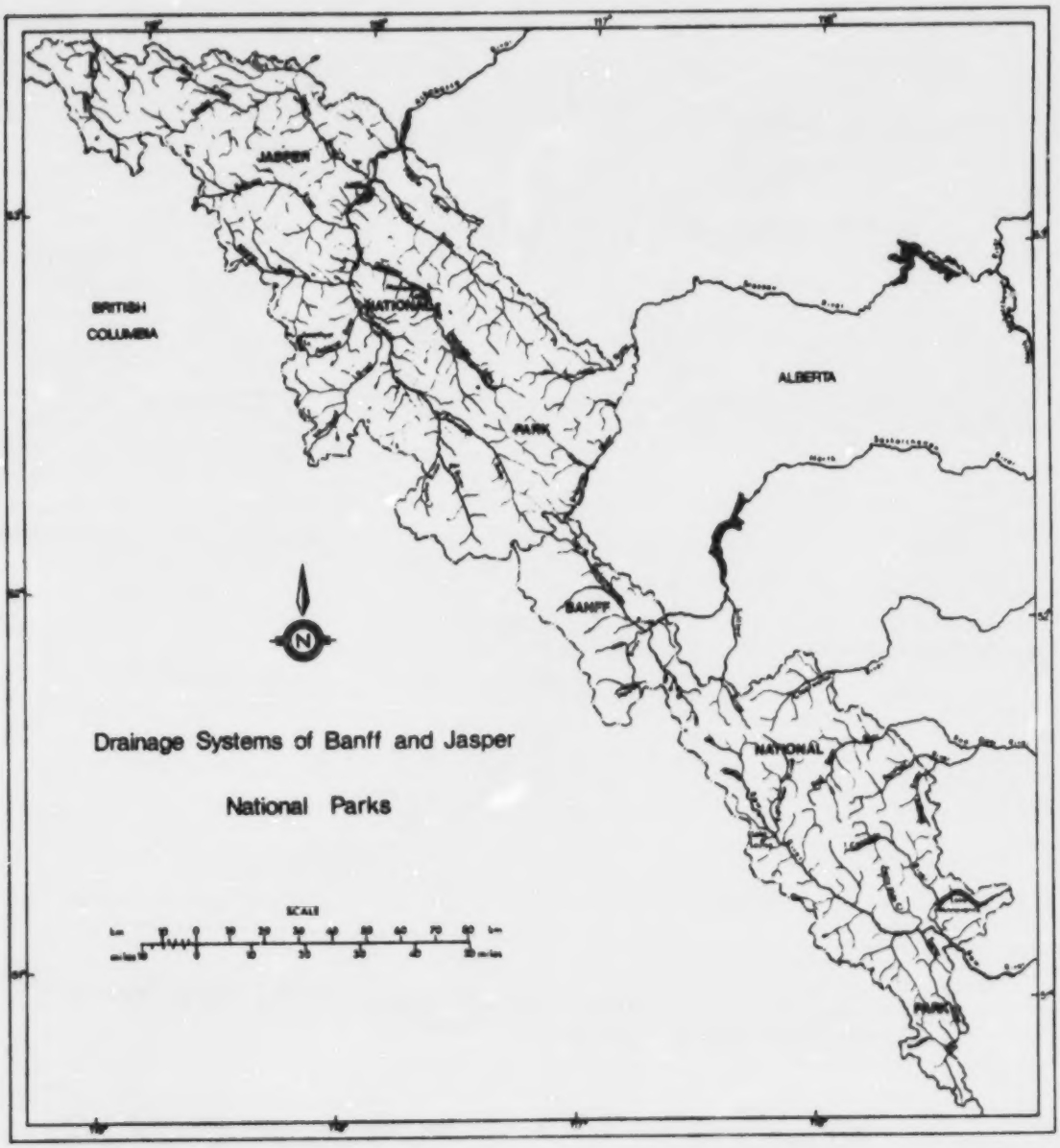


Figure 6 Drainage systems of Banff and Jasper National Parks.

created Lake Minnewanka as the largest lake in Banff. It has a surface area of 1295 ha, a maximum depth of 80 m, and occurs at an altitude of 1454 m. The next largest lakes are Hector (altitude:1737 m, area:688 ha), Bow (1981 m, 364 ha) and Peyto (1865 m, 194 ha) (Rawson 1939). Regardless of size, however, most of the lakes in Banff are important for recreation purposes.

Lakes in Banff and Jasper were formed in several ways. Some are dammed by landslides e.g. Moraine Lake, or by the moraine left by retreating glaciers e.g. Lake Louise and Amethyst Lake. Many result from damming by fans of tributaries where they join main streams in a valley bottom with a gentle gradient. Jasper Lake is presently dammed by fans of the Snake Indian and Rocky Rivers. Baird (1963) considers this to be a remnant of a former, much larger lake. Still others are formed in depressions either gouged out of bedrock or in stagnant ice moraine kettles.

Reports describing limnological studies (Ander-

son and Donald 1978, Donald and Anderson 1978) provide data on some of Jasper's larger lakes. Maligne Lake situated at an altitude of 1675 m, with surface area of 2066 ha and maximum depth of 96 m is the largest lake in the park. Other large lakes include Jasper (altitude: 10[illegible] m, area: 1085 ha), Amethyst (1967 m, [illegible] ha), Medicine (1442 m, 516 ha), Brazeau, and Twintree.

Medicine Lake is a karst lake which feeds an underground cave capable of transporting up to 57 m^3/s of water 17 km down-valley in 20 h (Brown 1973). During very high flows, usually mid-summer, Medicine Lake spills into the Lower Maligne River system directly. Later, however, as the water supply from melting snow diminishes, the lake shrinks and the Maligne River near the exit from Medicine Lake becomes a dry streambed. Flow at this time is entirely underground; by November the lake is almost completely drained (Baird 1963).

Hot springs located in the parks are important tourist attractions. The Cave and Basin Hot springs and the Upper Hot Springs are situated near Banff. Miette Hot Springs is located near the east entrance to Jasper National Park. The springs originate from rain, snow, and surface water that has seeped into fractures or pores in the rock and circulated to depths where the temperature of the rock is high. Part of the water is returned to the surface along fracture zones. On its way it mixes with various amounts of cool surface water resulting in hot springs of various temperatures (Baird 1963, Belyea 1964). Discovery of the Cave and Basin springs in 1883 led to designation of the area as Canada's first National Park (Belyea 1964).

SURFACE EXPRESSION

The main physiographic features of Banff and Jasper are subject to marked control by mountain building processes with stratified sedimentary rock. In addition, the landscape has been modified by extensive Pleistocene glaciation and post-glacial erosion and deposition. Vestiges of the former glaciation are visible in the small glaciers that remain at high elevations, mostly near the Continental Divide (Falconer et al. 1966). These retreating glaciers are still actively altering the landscape. Surface features resulting from the earlier glaciation are horns, arêtes, cols, cirques, truncated spurs, tarns, hanging valleys, and U-shaped valleys (Harrison 1976). Other glacial features are numerous morainal, glaciofluvial, and glaciolacustrine deposits. Eolian, fluvial, and colluvial postglacial processes have also modified the landscape. These glacial and postglacial features are further described under the geomorphology section, Ecosite descriptions, and the legend.

PHYSIOGRAPHY AND PEOPLE

The significance of the physiographic features is in their impact on the physical, chemical, and biological processes that form the environment of Banff and Jasper, and how these features affect land use in the parks. Self-evident relationships include: 1)amenable climatic and topographic combinations that make the Montane Ecoregion subject to the most intensive land use in Banff and Jasper; 2)the direction of the Athabasca and Bow River valleys, leading to the Yellowhead and Kicking Horse Passes respectively, and providing national transportation corridors with attendant land use pressures from highways, railways, oil lines, power lines, and service centres; and 3)the flat-lying structure and direction of the Main Ranges, which combined with the influence of aspect on glaciation, locate many of the lakes in cirque positions on the east side of individual ranges thus attracting people to these sites; e.g. the Ten Peaks area near Moraine Lake—Larch Valley in Banff, and the Ramparts of the Tonquin Valley in Jasper. The remainder of the report describes and locates natural resources, and may be referred to for a more detailed account of physiographic features.

GEOLOGY

W.S. Taylor

REGIONAL SETTING

Banff and Jasper lie in the southern portion of the Rocky Mountain Thrust Belt, the southeasterly most sector of the geological region known in Canada as the Cordilleran Orogen. This is part of a circum-Pacific orogenic belt that is generally some 800 km wide. Development of the Cordilleran Orogen is a result of the evolution of the Cordilleran Geosyncline from mid-Proterozoic to Recent time. At present the region is tectonically quiet (Douglas et al. 1970).

STRATIGRAPHIC FRAMEWORK

Broad trends of the depositional basin history are outlined by Douglas et al. (1970) and Price and Mountjoy (1970a). Geologic strata from late Proterozoic to early Mesozoic are represented in Banff and Jasper, as recorded in two separate stratigraphic sequences. The older, ranging in age from Hadrynian to Late Jurassic, represents a slowly subsiding miogeosyncline—shelf marine sequence. Sediments may be divided into detrital material (allogenic) derived from the North American craton to the northeast, and shallow water carbonates (authigenic). The second sequence, a clastic wedge, is non-marine and of Late Jurassic and Early Cretaceous age within the

parks. The rising Cordillera in the Columbian Orogen to the southwest was the probable source of these sediments (allogenic).

In general, purely allogenic sediments were devoid of carbonate, and became noncalcareous clastic rock (e.g. quartz sandstone, shale). While some chert and evaporites occur, authigenic minerals were principally carbonate, and became carbonate bedrock (e.g. limestone, dolostone). Mixtures of both were common, and are referred to as calcareous clastic (e.g. calcareous siltstone, argillaceous limestone).

Bedrock derived from the consolidation of these sediments has been systematically described and classified into rock-stratigraphic (lithology dependent) units (McLaren and Mountjoy 1962, Mountjoy 1962, 1964, 1965, Irish 1965, Norris 1965, Aitken and Norford 1967, Charlesworth et al. 1967, Gibson 1968a, 1968b, 1974, MacKenzie 1969, Cook 1975, Pugh 1975, McLean 1977, and many others). Much of this work has been summarized by Douglas et al. (1970). A schematic, generalized stratigraphic column for Banff and Jasper is compiled from Price and Mountjoy 1970a, b, 1978b, Jackson 1975, and Mountjoy 1980 (Fig. 7). For purposes of this report lithologies of these Groups and Formations are generalized into three categories:

1. noncalcareous, medium and coarse grained clastic,
2. noncalcareous, medium and fine grained clastic, and
3. carbonate and calcareous clastic.

STRATIGRAPHIC FRAMEWORK AND ECOLOGICAL LAND CLASSIFICATION

There is often a close relationship between the characteristics of surficial sediments and the source bedrock (Rutter 1972, Stalker 1973). More specifically, the three generalized bedrock lithology categories correlate with the three calcareousness and textural groups of unsorted genetic materials important in Banff and Jasper (Table 5).

Thus, there is an inferred link between the named rock-stratigraphic Groups and Formations (Figure 7) and ecosites described in this report, especially those on residual, colluvial and morainal genetic materials. Where these materials are noncalcareous and coarse textured, they are derived from any of the Gog Group, less commonly the Ishbel Group, or Mount Wilson, Misty (within Rocky Mountain Group), or Cadomin Formations. If the genetic materials are noncalcareous and medium textured, they are likely derived from the Miette or Fernie Groups, the Kootenay, Nikanassin or Luscar Formations, or less commonly part of the Arctomys Formation. The balance of the Groups and Formations produce calcareous, medium textured unsorted sediments(Table 5).

STRUCTURAL FRAMEWORK

The broad structural and tectonic elements of the Rocky Mountain Thrust Belt are outlined by Douglas et al. (1970) and discussed more specifically by Price and Mountjoy (1970a). The portion of this belt containing Banff and Jasper was produced by the Laramide Orogeny over the period from late Upper Cretaceous to mid-Tertiary (Oligocene). Sediment deformation is of the decollement (independent of crystalline basement rock) type, with little or no metamorphism, volcanism, or plutonism. One diabase dyke occurs near Bow Lake in Banff (Price and Mountjoy 1978a). Some sediments of the early miogeosyncline have undergone low-grade metamorphism. Dominant structural features are discrete, discontinuous, interleaved, and overlapping thrust faults. The thrust sheets typical of the Rocky Mountains were northeasterly foreshortened along these faults and are now stacked on the flank of the North American craton.

The present degree of erosion subsequent to orogeny has resulted in a series of subparallel, northwest-southeast trending geological subprovinces separated on the basis of their distinctive stratigraphy, structure, and topography. Boundaries often correspond to fault traces, but these are not necessarily contiguous. From east to west these subprovinces are the Foothills, Front Ranges, Main Ranges, and Western Ranges.

The Western Ranges subprovince does not occur in Banff or Jasper. While opinion

Table 5 Correlation of generalized bedrock lithology with calcareousness and texture groups of unsorted genetic materials.

Generalized Bedrock Lithology	Calcareousness and Texture of Unsorted Genetic Material
Noncalcareous, medium and coarse grained, clastic	Noncalcareous, coarse textured
Noncalcareous, medium and fine grained, clastic	Noncalcareous, medium textured
Carbonate and/or calcareous clastic	Calcareous, medium textured

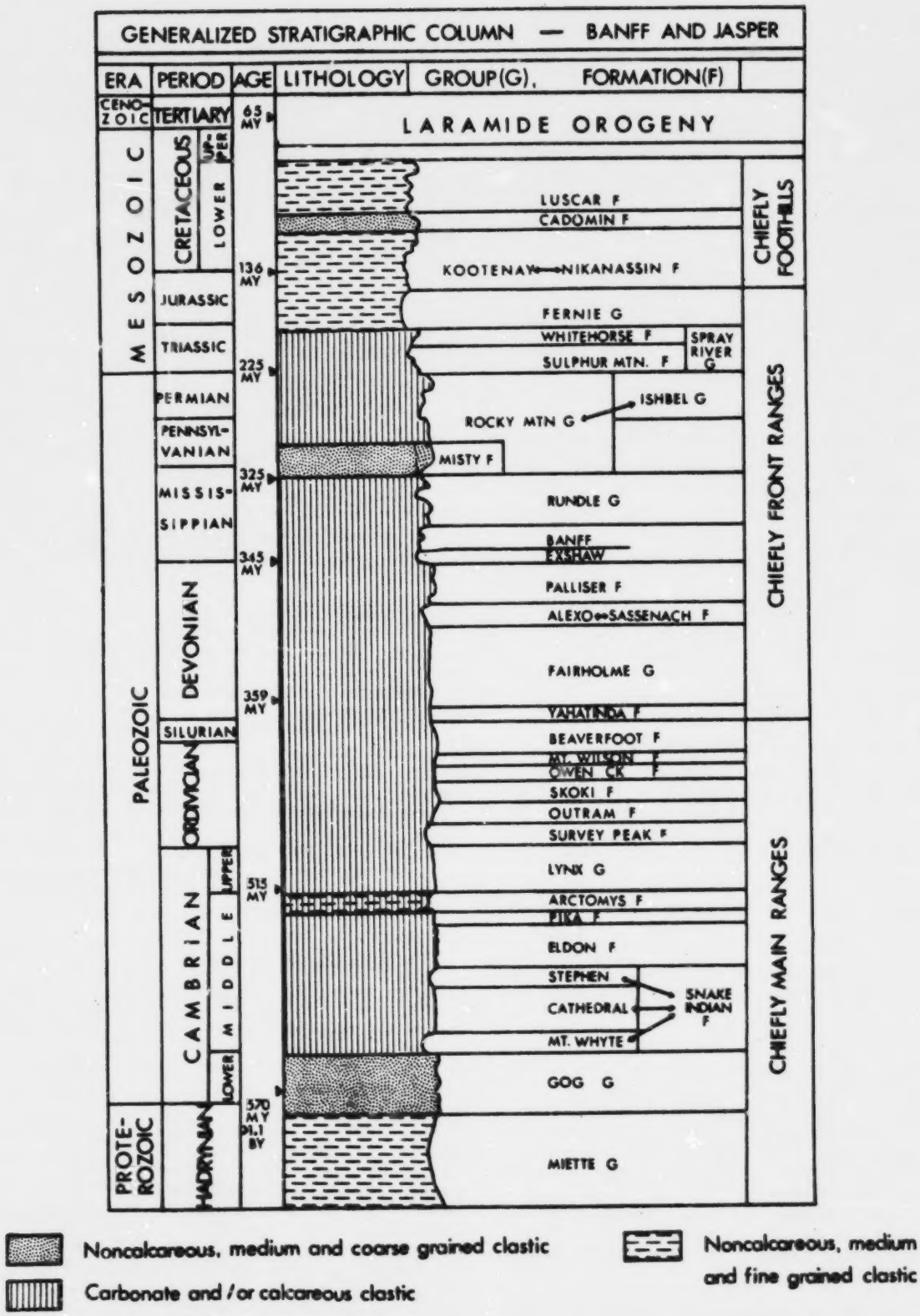


Figure 7 Generalized time scale and stratigraphic column for Banff and Jasper.

varies, especially about Jasper's eastern boundary from Rock Creek south to the Brazeau River (Lang 1947, Mountjoy 1964, Irish 1965, Gibson 1968a, Price and Mountjoy 1970a, Pugh 1975), the consensus is that, except for a small triangular peninsula between the Southesk and Brazeau Rivers, the Foothills subprovince also is effectively excluded from the parks. However, Foothills characteristics occur locally within the eastern side of both parks where topography is subdued (forested plateaus and rounded ridges) and bedrock is comprised of the previously mentioned Mesozoic clastic wedge sediments.

The Front Ranges subprovince is regionally recognized by the dominant exposure of steeply southwest dipping Devonian to Jurassic rocks. These are arranged in rugged subparallel ridges of resistant Paleozoic carbonate peaks separated by valleys carved from the less resistant Mesozoic clastic rocks.

The relative flatness of the thrust plates in the Main Ranges subprovince results in beds that are gently dipping, with broad and open folds. Erosion has carved mountain ranges that are far less linear than the Front Ranges into the more competent pre-Devonian sequence that is characteristic of the Main Ranges. Typically, mountains are capped by resistant Paleozoic carbonates and grade downwards in both time and elevation to valley walls composed of the earlier clastic sediments of the miogeosyncline, deposited in the late Hadrynian and early Cambrian.

Fig. 4 sketches the distribution of the Foothills, Front Ranges, and Main Ranges in Banff and Jasper as compiled from Douglas (1969), Price and Mountjoy (1970a), Green (1972), Cook (1975), Jackson (1975), Pugh (1975), and Mountjoy (1980). Interpretation is least reliable in extreme southern Banff.

STRUCTURAL FRAMEWORK AND ECOLOGICAL LAND CLASSIFICATION

The structural framework gives information about distribution of the named bedrock units within the parks through the vehicle of subprovince. Formations and Groups typical of each of the Foothills and Front and Main Ranges are indicated in Fig. 7. The link between these rock-stratigraphic units and the Ecosites of this Ecological Land Classification is discussed earlier. The addition of structural information (via location) allows a closer correlation of these Ecosites to specific bedrock. As an example, the source strata for an Ecosite mapped on noncalcareous, medium textured glacial till located in the Main Ranges were probably of the Miette Group (Figs. 7,4, Table 5).

Distribution of Groups and Formations, as shown on geological maps, is strongly correlated with Ecosite distribution, especially those occurring on unsorted genetic materials with a restricted bedrock source. Geological maps complementing this Ecological Land Classification to which the reader is referred, are by Price and Mountjoy (no date), Mountjoy (1960, 1964), Price and Mountjoy (1970a,b, 1971a,b, 1972a,b), Cook (1975), Price et al. (1978, 1979), and Mountjoy (1980).

Several other positive correlations between this study and bedrock geology are noted throughout the text of this report.

GEOMORPHOLOGY

B.D. Walker, D.T. Allan, and W.S.Taylor

INTRODUCTION

Soil and vegetation development is influenced by landform. Landform consists of genetic material, surface expression, and modifying processes (C.S.S.C. 1978b). This section describes characteristics of landform relevant to Ecological Land Classification in Banff and Jasper.

Genetic material is most important because it provides the framework within which to classify and interpret other properties of the landscape. Consequently, genetic materials are emphasized in the following descriptions. Surface expression describes landscape form but is often dependent upon genetic material (i.e. mode of deposition). Modifying processes occasionally influence landscape form but are more important in aiding classification and interpretation of other landscape properties, particularly soils and vegetation. Some processes are genetic material specific. Both surface expression and modifying processes are discussed under the genetic material descriptions following.

LANDFORM CLASSIFICATION

Landform classification follows, with modification, the system outlined by C.S.S.C. (1978b). Reimchen and Bayrock (1975) mapped and described, for Banff and Jasper, similar groups of genetic materials using a terrain analysis system patterned on that of Fulton et al. (1974). Genetic materials are organized into four groups (components), namely consolidated (bedrock), unconsolidated mineral, organic, and ice. The bedrock and ice components lack soil and vegetation and are not further subdivided. The organic component is of limited areal extent and thinly mantles unconsolidated mineral deposits. Because most soil and vegetation in Banff and Jasper occur on the unconsolidated mineral group it is therefore emphasized in the following discussion.

The unconsolidated mineral group is subdivided according to mode of formation or deposition. Ten genetic material classes (modified from C.S.S.C. 1978b) are recognized. These are listed in Table 6 in order of increasing source diversity, increasing influence on properties by depositional agents, and decreasing bedrock lithology influence. Residual material (R^U—Rock, modified by the qualifying descriptor Unconsolidated) is similar to saprolite as defined by C.S.S.C. (1978b) except for grain size properties and kind of weathering. Landslide material (C^A—Colluvium, modified by the qualifying descriptor Avalanched) is a subset of colluvial material, as defined by C.S.S.C. (1978b), herein differentiated to accomodate cataclysmic colluvial processes. The ice contact stratified drift (MF^G—Moraine and Glaciofluvial) class, undefined by C.S.S.C., accomodates polygenetic, stratified glacial drift, its components being inseparable at the 1:50,000 map scale. Fluviolacustrine material (F^L— Fluvial material modified by the qualifying descriptor Lacustrine) fits neither the fluvial nor lacustrine classes defined by C.S.S.C. (1978b) and encompasses sediments deposited in low energy fluvial environments.

Genetic material classes are further subdivided according to textural and chemical (calcareousness) properites imparted either by source area lithology or modified by the depositional media. Twenty genetic material units, listed in Table 6, are defined specifically for the Banff - Jasper Ecological Land Classification. To organize textural variability for convenience of presentation, the textural classes defined by C.S.S.C. (1978a) are grouped into coarse, medium, fine, coarse textured and stratified, fine textured and stratified, and variable categories. Each group is defined specifically for the genetic material unit to which it applies. Similarly, the calcareousness classes defined by C.S.S.C. (1978a) are generalized into three major groups: noncalcareous, calcareous, and altered. The first two are defined specifically, in terms of $CaCO_3$ equivalent and reaction (pH), for the genetic material units to which they apply. The altered group encompasses materials in the weathering (pedogenic) zone; consequently, original calcareousness and reaction are unknown. Occasionally, a variable calcareous group is used to combine calcareous and noncalcareous materials at the study scale.

RESIDUAL GENETIC MATERIAL

Residual material in Banff and Jasper is physically and chemically weathered bedrock and is designated by the landform symbol "R^U". It is similar to saprolite (C.S.S.C. 1978b) in that the present texture is a relic of the chemically altered rock. However, particle sizes beyond silt and clay are included in Banff and Jasper. Secondly, physical weathering of highly jointed bedrock results in material that is neither coherent nor has original grain relationships maintained. Thirdly, R^U includes failed bedrock that retains some original bedding structure and, though extremely jointed and somewhat displaced, is nonfragmental.

Residuum is produced by frost activity along jointing (joint-block separation). The resulting increased surface area is then subject to weathering of the cement holding grains of the rock together. This process is still active on most residual material in the parks.

Residual material is derived from recessive bedrock; factors that make bedrock recessive also make it residuum-producing. These include relative softness, laminated bedding, low degree of cementation, weatherable cement, and others. Most residual material in the parks is medium textured, derived from medium and fine grained clastic rock, either calcareous or noncalcareous. Structural setting is also important. Strata in the Front Ranges were generally less competent during orogeny than those in the Main Ranges (Price and Mountjoy 1970a), the greater weakness and deformation in the Front Ranges generating extensive areas of highly jointed bedrock.

Elevation and topography influence residual material distribution. In the Montane, residuum is scarce, and in the Subalpine rare and expressed mainly as postglacial failed bedrock, because glacial and more recent unconsolidated materials cover nearly all of the in situ recessive rock. This occurs despite the carving of valleys, especially in the Front Ranges from this potentially residuum-producing rock (Price and Mountjoy 1970a). However, in the Alpine, residuum is best expressed. Plate 1 shows an Alpine landscape of this material on Copper Mountain in Banff. The area was glaciated, as indicated by an erratic, but the material covering the landscape has originated almost exclusively through weathering. Stalker (1973) and Harrison (1976) report that some high elevation areas in the Rockies escaped glaciation. Though inconclusive, the presence of well developed soils and well established vegetation on some Alpine residuum versus incipient, unvegetated Regosols on other apparently comparable sites suggests some of the former escaped glaciation (cf Plates 1 and 126).

Residuum on high broad plateaus and in lower passes that have been glaciated is sometimes locally mixed with till. Altered medium textured eolian material (Eolian material B) may mantle or be mixed with it as well.

As previously discussed, textures are medium and controlled by lithology. However, a con-

Table 6 Characteristics of modal unconsolidated mineral genetic materials within Banff and Jasper.

	Medium	Genetic Material Symbol*	Genetic Material Class†	Characteristics: Calcareousness	Characteristics: Texture	Genetic Material Unit
Genetic material derived from increasingly diverse bedrock lithology	Rock *(in situ* and failed)	R^{U*}	Residual	noncalcareous	medium	Residuum A
				calcareous	medium	Residuum B
		C^{A*}	Landslide	variable	variable	Landslide material
	Gravity	C	Colluvial	noncalcareous	coarse	Colluvium A
				noncalcareous	medium	Colluvium B
				calcareous	medium	Colluvium C
	Ice	M	Morainal	noncalcareous	coarse	Till A
				noncalcareous	medium	Till B
				calcareous	medium	Till C
		MF^{G*}	Ice Contact Stratified	noncalcareous	coarse	Ice Contact Stratified Drift A
				calcareous	variable	Ice Contact Stratified Drift B
	Flowing Water	F^{G}	Glaciofluvial	noncalcareous	coarse	Glaciofluvial material A
				calcareous	coarse	Glaciofluvial material B
		F	Fluvial	noncalcareous	coarse-stratified	Fluvial material A
				calcareous	coarse-stratified	Fluvial material B
		F^{L*}	Fluviolacustrine	altered	fine-stratified	Fluviolacustrine material A
	Still Water			calcareous	fine-stratified	Fluviolacustrine material B
		L^{G}	Glaciolacustrine	calcareous	fine	Glaciolacustrine material
	Air	E	Eolian	calcareous	medium	Eolian material A
				altered	medium	Eolian material B

Restricted bedrock source / *Increasingly diverse sources*

Unsorted / *Increasingly sorted*

* The abbreviations used to designate Genetic Materials are according to C.S.S.C. 1978b except for R^{U}, C^{A}, MF^{G}, and F^{L} which are defined in this section.

† Modified from C.S.S.C. (1978b) as outlined under Landform Classification in this section.

tinuum of chemical properties from noncalcareous, acid, to highly calcareous, alkaline exist. For purposes of this Ecological Land Classification, this continuum was broken into two genetic material units. These are Residuum A (essentially noncalcareous) and Residuum B (calcareous), with characteristics as discussed below.

RESIDUUM A

Concept and Distribution

Residuum A is noncalcareous, medium textured material derived by the in situ physical and chemical weathering of noncalcareous, medium to fine grained clastic bedrock. Residuum A is the dominant residuum in the Main Ranges. There, Miette Group strata produce most of this residual material mapped in Ecosites. However, Residuum A from recessive bedrock of the Main Ranges' upper stratigraphic column (e.g. Arctomys Formation) is sometimes included in the Miscellaneous Landscape Colluvial Rubble (CR) on gentle slopes. In the Front Ranges, medium grained bedrock of the Fernie Group and younger produces Residuum A (Fig. 7). Other aspects of distribution have been previously discussed.

Surface Expression and Modifying Processes

Most surfaces of Residuum A are inclined, hummocky, or ridged. Inclined examples are usually convex, some to the point of being dome-like on broad mountain ridges. These indicate homogeneous bedrock, or that a uniform bed of the residuum-producing bedrock conforms closely to the ground surface. Hummocky expression is usually associated with postglacial failure of bedrock and is proportionately more common in the Subalpine. Ridged expresssion indicates that surfaces truncate differing strata where beds dip at an angle relative to the surface.

Slopes are mostly complex, and range up to 45%. Material on the steeper of these is transitional to colluvium as gravity induced movement becomes evident, especially by solifluction in the Alpine. Cryoturbation is also common in the Alpine on this material.

Textural Properties

Residuum A is normally medium textured, with sand content ranging from 20 to 60%, clay from 5 to 20%. These values occupy part of the silt loam, loam, and sandy loam textural classes of C.S.S.C. (1978a).

Content of fine earth decreases and coarse fragment content increases with depth in sola developed on Residuum A. Coarse fragment content ranges from 50 to 90% by volume in lowest least altered horizons. Fragments are angular gravelly and cobbly as defined by C.S.S.C. (1978a) when derived from siltstone and sandstone, but are more often channery or slaty from the Miette Group and shaly from Mesozoic strata. Fragments of these latter three categories are often breakable with hand force. Sample preparation therefore can strongly influence grain size determinations.

Calcareousness and Reaction Properties

Residuum A is usually noncalcareous, hence acid, ranging from extremely to medium acid (C.S.S.C. 1978a) with pH values between 4.5 to 6.0. In the low lime phase transitional to Residuum B, separation of these materials is based on pH of the sola developed on them. Specifically, Residuum A produces sola with pH $\leq$5.5 to a depth of 25 cm below the top of the B horizon. This ranges up to about 5% $CaCO_3$ equivalent.

Discussion

Residuum A is the principal genetic material of the Copper (CP) Ecosection, and is a common constituent of the Brazeau (BZ) Ecosection and the Heather 1 (HE1) Ecosite. It is an occasional constituent of the CR Miscellaneous Landscape as discussed earlier (e.g. between upper Dolomite Creek and the Mistaya River in Banff).

Residuum A is separated from colluvium by the steep topography and generally fragmental nature of the latter. Till has diverse lithology, is more compacted, and is lower in coarse fragment content. Residuum B is the calcareous counterpart of Residuum A.

RESIDUUM B

Concept and Distribution

Residuum B is calcareous, medium textured material derived from the in situ physical and chemical weathering of calcareous clastic bedrock. Residuum B is primarily distributed in the Front Ranges. There the Spray River Group is the principal bedrock source. Most Residuum B is mapped in Ecosites. However, some is included in the Miscellaneous Landscape Colluvial Rubble (CR) often on gentle slopes on recessive bedrock in the Main Ranges upper stratigraphic column.

Surface Expression and Modifying Processes

Most surfaces of Residuum B are inclined, hummocky, or ridged. Inclined examples are usually convex, some to the point of being dome-like on broad mountain ridges. These indicate homogeneous bedrock or that a uniform bed of the residuum-producing bedrock conforms closely to the ground surface. Hummocky expression is usually associated

with postglacial failure of bedrock and is proportionately more common in the Subalpine. Ridged expression indicates that surfaces truncate differing strata where beds dip at an angle relative to the surface.

Slopes are mostly complex, and range up to 45%. Material on the steeper of these slopes is transitional to colluvium as gravity induced movement becomes evident, especially by solifluction in the Alpine. Cryoturbation is also common in the Alpine on this material.

Textural Properties

Residuum B is normally medium textured, with sand content ranging from 20 to 60%, clay from 5 to 20%. These values occupy part of the silt loam, loam, and sandy loam textural classes of C.S.S.C. (1978a).

Content of fine earth decreases and coarse fragment content increases with depth in sola developed on Residuum B. Coarse fragment content ranges from 50 to 90% by volume in lowest, least altered horizons. Fragments are most frequently angular gravelly and cobbly as defined by C.S.S.C. (1978a), but some channery, shaly, and flaggy examples occur. Fragments are generally coherent and resist breakage, except for shaly material.

Calcareousness and Reaction Properties

Residuum B is usually calcareous, hence neutral to moderately alkaline in reaction. Calcium carbonate equivalent is inferred to be generally <35% with pH ranging from 7.0 to 8.0. In the low lime phase transitional to Residuum A, separation of these materials is based on pH of the sola developed on them. Specifically, Residuum B produces sola with pH >5.5 to a depth of 25 cm below the top of the B horizon. This ranges down to about 5% $CaCO_3$ equivalent.

Discussion

Residuum B is a common constituent of the Brazeau (BZ) Ecosection and the Heather 1 (HE1) Ecosite. It is occasionally a constituent of the CR Miscellaneous Landscape as discussed earlier (e.g. between upper Dolomite Creek and the Mistaya River in Banff).

Residuum B is separated from colluvium by the steep topography and generally fragmental nature of the latter. Till has diverse lithology, is more compacted and is lower in coarse fragment content. Residuum A is the non-calcareous counterpart of Residuum B.

LANDSLIDE GENETIC MATERIAL

Landslide genetic material in Banff and Jasper is the deposit generated following rapid, gravity-induced movement of mineral material downslope en masse. C.S.S.C. (1978b) includes this process in the definition of avalanche and considers the material to be colluvial. Thus, as used in this report the terms landslide and colluvial avalanche ($C^{\wedge}$) are synonymous. An outline of the scope of the term landslide is given by Gary et al. (1972).

Landslides are sporadically distributed throughout the parks. Usually they were derived from failed bedrock of various lithologies,but occcasionally they originated from preexisting unconsolidated mineral material (e.g. mid-Dolomite Creek valley in Banff). Thus, most unaltered landslide material contains little fine earth, a feature that strongly influences initial soil and vegetation development. Because of the unreliability of lithology interpretation in material derived from a specific local source, limited occurrence, and the controlling influence of coarse fragment content, landslide material was not further subdivided.

LANDSLIDE MATERIAL

Coarse Fragments

Coarse fragments comprise 50 to 100% of the material by volume in landslide deposits. Slides generated from massive, resistant bedrock have blocky coarse fragments (angular fragments >256 mm), occasionally as large as house-sized. Those from highly jointed recessive bedrock are often mixed rubbly (angular fragments <256 mm) and blocky, and have more fine earth associated with them. Soil and vegetation develop more rapidly on the finer grained slides, while coarsest portions often continue to have sparse soil and vegetation regardless of age. Much of the fine earth fraction in soils on older slides is altered medium textured eolian material (Eolian material B). Sola developed on landslide material from failed bedrock are generally fragmental at depth. Surfaces are often exceedingly to excessively stony.

Fine Earths

Calcareousness properties of landslide material range from non- to extremely calcareous, and both extremes may occur within one slide derived from contrasting materials. Textures, where fine earths occur, are variable from medium to coarse, spanning silt loam, loam, sandy loam, and loamy sand as defined by C.S.S.C. (1978a). Fig. 8 illustrates textural variation among selected C horizons of pedons sampled on landslide material. Exclusive of eolian addition to surfaces, textures often reflect the nature of material prior to failure, as landslide events in themselves do not greatly modify texture. Subsequent weathering liberates preexisting cemented grains, thereby controlling texture.

Surface Expression

Surface expression of landslide material is hummocky, often superimposed on a rising slope. Hummocks are produced by the land-

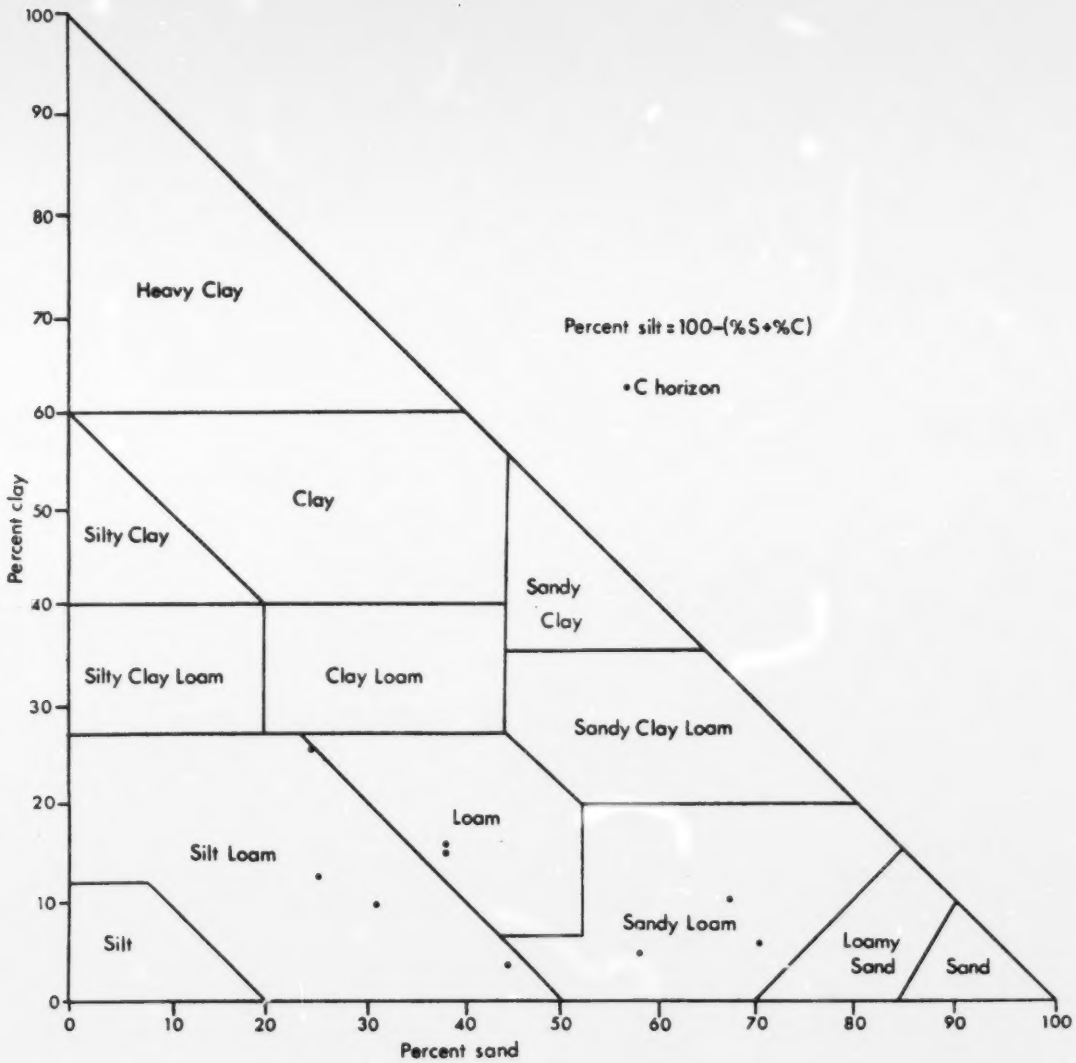


Figure 8 Textural variation among selected C horizons sampled on landslide material.

slide process, while the overall incline reflects bedrock control at some depth.

Thickness of landslide material is variable, controlled by individual factors for each slide such as volume of material, height of failure above the valley floor, steepness and channelling during the failure, type of terrain covered, and others. Most landslides are postglacial and immediately overlie a variety of unconsolidated materials, especially till on valley walls and lower slopes.

Discussion

Landslide material is separated from other colluvial material on the basis of its cataclysmic genesis. Other colluvium occurs on linear steeply inclined slopes and on average has smaller coarse fragments and a higher fine earth content.

Residuum on failed slopes is similar to landslide material but is not fragmental. Less violence is inferred in genesis of the former, as some structures remain intact despite an increase in the degree of jointing and displacement of beds.

Landslide material forms the principal landforms of the Garrone (GA) Ecosection in the Montane, Ishbel (IB) in the Lower Subalpine, and Boulder Pass (BP) in the Upper Subalpine, as well as the Miscellaneous Landscape Colluvial Landslide (CL). In the Alpine, a few tracts of Bow Summit 1 (BS1) are mapped on landslide material.

Many conditions can precipitate landslides,

but one of the most common is dip-slope failure due to undercutting or removal of lateral support (Cruden 1976). Plate 2 illustrates a valley wall in Jasper near Nigel Pass where this type of landslide has occurred and has the potential for further failure. A less common type of landslide from Dolomite Creek in Banff is shown in Plate 3. A rock glacier is interpreted to have spilled en masse over a cliff above the landslide. Melting of frozen blocks of unconsolidated material left the conical debris piles.

COLLUVIAL GENETIC MATERIAL

Colluvium is defined as any loose, heterogeneous, and incoherent mass of soil material and rock fragments deposited chiefly by gravity (Gary et al. 1972). Movement includes slow displacement such as soil creep and rapid events such as landslides, avalanches and rockfalls (C.S.S.C. 1978b). For purposes of the Banff-Jasper Ecological Land Classification, landslide and colluvial genetic materials were separated, the latter refering specifically to deposits generated by slow displacement and/or rapid motion of isolated fragments.

Colluvial genetic material is postglacial and modifies chiefly steep, glaciated valley walls. Surface form is usually linear and expressed as blankets, veneers and aprons, and is controlled by deposition and underlying bedrock. Colluvial material is generally shallowest (veneers) at the top of slopes and deepens downslope (blankets). Aprons occur along slope bases at major slope breaks and below steep rock walls. Irregular surface form occurs when the continuity of colluvial slopes is broken by one or more bedrock escarpments. Bedrock escarpments are common on some colluvial slopes. Colluvial veneers dominate on some slopes where colluvial deposits are thin over bedrock. Slopes on colluvial landforms are commonly 55 to 70% and range from 45 to 100%.

Soil creep (slow down slope colluviation of soil and rock) has been instrumental in forming many of the colluvial deposits in Banff and Jasper. Presently, active soil creep affects surface layers, thereby influencing soil development. Its effects on surface form and genetic material are negligible.

Snow avalanching is characteristic on some colluvial slopes. Varying amounts of material are deposited downslope during avalanche events. However, avalanche related fluvial activity is important to material accumulation on aprons below channelled tracks and couloirs. Fluvial material including mudflow deposits thinly mantle and interbed with colluvial material.

Other processes affecting colluvial landforms include slope failure, surface (sheet) erosion, solifluction and cryoturbation. Slope failure occurs on a few colluvial landforms and primarily encompasses slow mass movement (often rotational) of unconsolidated material plus partial failure of underlying bedrock downslope along a slip surface. Surface sheet erosion occurs locally and affects the upper sola of soils. Solifluction and cryoturbation occur infrequently, usually at high elevations.

The Miscellaneous Landscapes Talus (T) and Colluvial Rubble (CR) are also colluvial material.

The textural and chemical characteristics of colluvial material reflect source bedrock lithology. Continua of textural (coarse to fine) and chemical (from noncalcareous and alkaline) properties exist in the colluvial deposits of Banff and Jasper. For the purposes of this Ecological Land Classification the continua are categorized into three colluvial genetic material classes. Separation is based on textural and calcareousness properties reflected by three major categories of bedrock lithology (Table 5). The three colluvial genetic materials are: noncalcareous, coarse textured colluvium (Colluvium A) derived from medium to coarse grained, noncalcareous clastic strata; noncalcareous, medium textured colluvium (Colluvium B) derived from medium to fine grained, noncalcareous clastic strata; and calcareous, medium textured coiluvium (Colluvium C) derived from medium to fine grained, carbonate and calcareous clastic strata (Table 5).

COLLUVIUM A

Concept and Distribution

Modally, Colluvium A is noncalcareous (acidic), coarse textured colluvium derived from medium to coarse grained, noncalcareous clastic bedrock, mainly quartzite. Its major source is the Lower Cambrian Gog Group that dominates portions of the Main Ranges. Occasional occurrences are correlated to the Ordovician Mount Wilson Formation (e.g. near Pipestone Pass warden cabin in Banff) and quartz sandstone layers of the Permian-Pennsylvanian Rocky Mountain Group (e.g. north of Cascade Mountain in Banff). Colluvium A is the least extensive of the three colluvial genetic materials. Ecosites with Colluvium A as the principal genetic material are restricted to the Subalpine and Alpine Ecoregions. In the Lower Subalpine, colluvial landforms occasionally are admixtures of Colluvium A and Colluvium B. Some Main Range slopes at low elevations, where Gog Group quartzites are underlain by Precambrian Miette Group slates and shales, have colluvium composed of debris falling from both groups.

Surface Expression and Modifying Processes

Colluvial slopes consisting of Colluvium A

commonly occur as blankets and veneers overlying inclined bedrock on steep valley walls and as aprons along slope bases at major slope breaks and below steep rock walls. Exposed bedrock forms the subdominant portion of some colluvial slopes. Surface form is controlled by the amount of deposition and by the underlying bedrock. Colluvium A landforms have dominantly linear, inclined slopes commonly ranging from 45 to 100%. Colluvium A slopes with complex topography have linear slopes whose continuity is broken by one or more exceptionally steep bedrock escarpments.

Soil creep is a common surface modification affecting landforms comprised of Colluvium A. Soil creep indicates active colluviation affecting surface layers but its effects on surface form and genetic material characteristics are negligible. Effects on soil development, however, are significant.

Snow avalanching is characteristic of some colluvial slopes. Varying amounts of material are deposited down slope during avalanche events, therefore its effects on parent material and associated soils are variable. Its effects on surface form are virtually negligible but its effects on vegetation are great. Avalanche related fluvial activity is important to material accumulation on aprons below channelled tracks and couloirs. Fluvial material thinly mantles and interbeds with colluvial material.

Other processes affecting Colluvium A include slope failure, surface sheet erosion, solifluction and cryoturbation. Slope failure encompasses slow mass movement, often rotational, of unconsolidated material plus partial failure of underlying bedrock downslope along a slip surface. Such failed slopes are postglacial and, in some instances may still be active. Surface sheet erosion occurs locally and affects the upper sola of soils. Solifuction and cryoturbation occur infrequently, the latter only in the Upper Subalpine and Alpine.

Textural Properties

Colluvium A is coarse, referring to both texture and volume of coarse fragments. The fine earths are generally comprised of 60 to 85% sand and 0 to 10% clay. This range falls within the sandy loam and loamy sand textural classes defined by C.S.S.C. (1978a). Textural variation among selected Bm, BC and C horizon samples of Colluvium A is portrayed in Fig. 9. Angular coarse fragments, dominantly quartzite, commonly constitute 50 to 90% and occasionally 100% by volume of Colluvium A. Shaly and slaty fragments mix with quartzites on some colluvial slopes where Gog Group strata are underlain by Miette Group strata. Carbonate fragments are rare or absent.

Colluvium A and C are differentiated by textural and chemical properties; Colluvium A and B primarily by textural properties. Where it is necessary to differentiate phases of Colluvium A and B that have similar textures (e.g. in the 50 - 70% sand range), accessory features, including coarse fragments, soil development, and location are used. Colluvium A has the highest content of coarse fragments, most of which are quartzitic. Shale, slate or carbonate fragments are rare or absent. Stones and boulders are especially abundant in Colluvium A, its surfaces often being very stony.

Soils developed in Colluvium A are distinctive. They usually have deeply weathered sola, and thick, well developed eluvial (Ae) horizons, which are indicative of rapidly pervious, noncalcareous, coarse textured genetic material. Soils developed in Collvuium B and C genetic materials have thin sola with thin to absent Ae horizons.

Finally, Colluvium A, B and C are differentiated by the nature of the lithology of the bedrock outcrop from which the Colluvium was derived. Colluvium A is situated below cliffs or outcrops comprised of quartzites.

Calcareousness and Reaction Properties

Colluvium A is usually noncalcareous and acid, with pH values commonly ranging from 4.3 to 6.0. A low lime phase (<15% $CaCO_3$ equivalent) with higher pH (6.0 to 7.0) occurs locally but is characterized by deeply weathered, acidic soils. The low lime phase occurs when minor amounts of calcareous beds occur in the strata from which the colluvium is derived.

Colluvium A and B have similar low lime and low pH properties; whereas Colluvium C is usually chemically different but can have similar low lime phases. These are distinguished by textural and related properties and by associated soil development. Colluvium A is distinguished from Colluvium C because it is dominated by deeply weathered soils with extremely to strongly acidic (pH 5.5 or less) sola including, specifically, the B and underlying horizons to a thickness of 25 cm. Soils developed in the low lime phase of Colluvium C have medium acid to neutral (pH >5.5) lower sola.

Discussion

Colluvium A is noncalcareous and coarse textured, being derived primarily from quartzitic bedrock. It is least extensive of the three colluvial parent materials differentiated in Banff and Jasper. The Endless Chain (EN) and Tekarra (TK) Ecosections occur on colluvial slopes consisting of Colluvium A. The Fairview (FV) Ecosection occurs on colluvial slopes consisting of Colluvium A and/or Colluvium B.

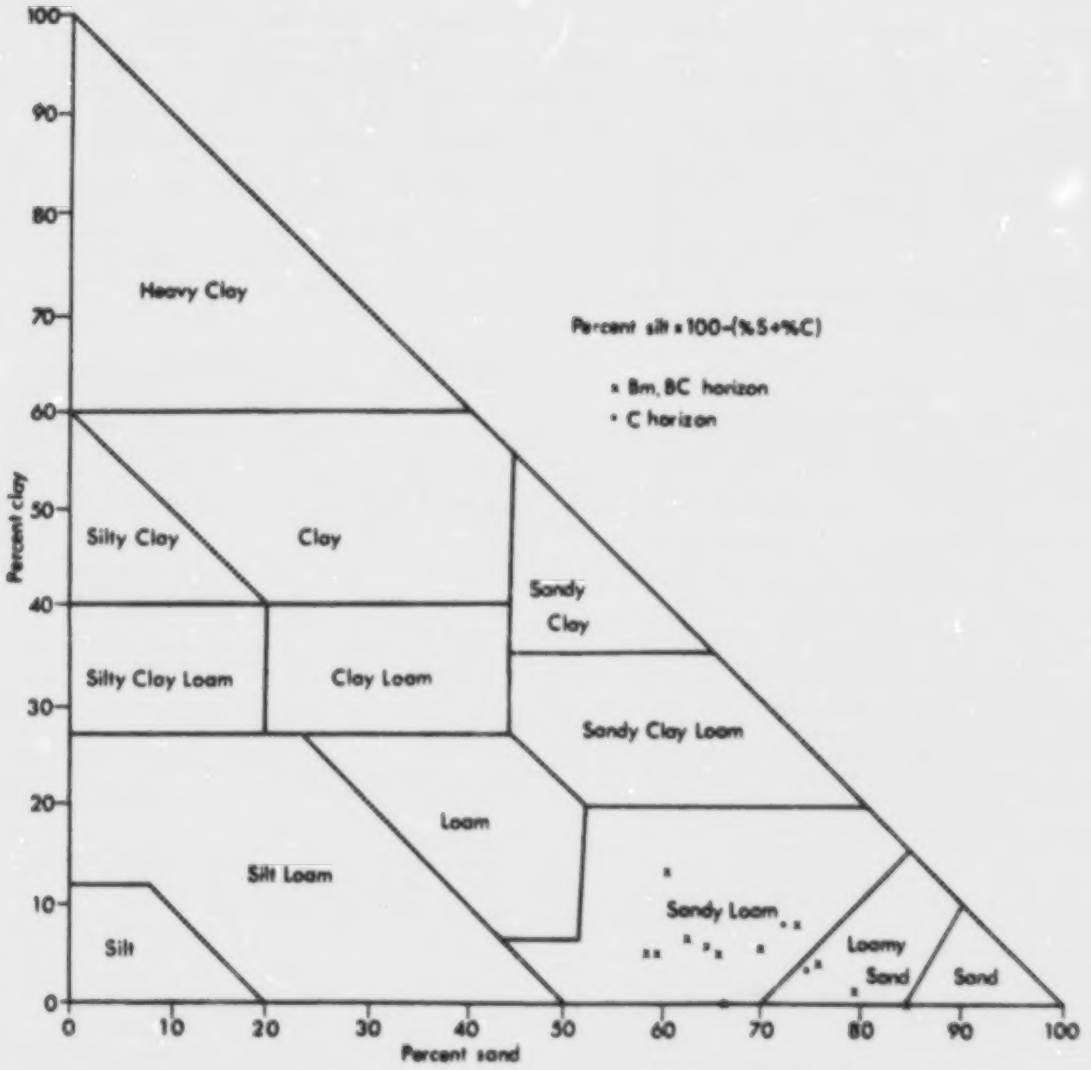


Figure 9 Textural variation among selected Bm, BC, and C horizon samples of noncalcareous, coarse textured colluvium (Colluvium A).

Miscellaneous Landscapes Talus (T) and Colluvial Rubble (CR) consist of Colluvium A in areas dominated by Gog Group strata.

COLLUVIUM B

Concept and Distribution

Modally, Colluvium B is noncalcareous (acidic), medium textured, colluvium derived from medium to fine grained, noncalcareous, clastic bedrock, mainly shale and slate. Its major source is the Precambrian Miette Group (slate and shale) that dominates portions of the Main Ranges geologic subprovince. Colluvium B also occurs in the Front Ranges but not as extensively. Colluvial materials in these eastern areas are derived from the noncalcareous, often carbonaceous, Mesozoic strata, namely the Jurassic and Lower Cretaceous strata of the Kootenay, Nikanassin and Luscar Formations and the Fernie Group. Colluvium derived from the Mesozoic sources is darker colored (dark browns and grays to black) than colluvium derived from the older strata (yellowish browns and browns).

Colluvium B is more extensive than Colluvium A. Colluvium B source areas are characterized by a distinctive subdued mountain landscape formed entirely in the recessive Miette Group and noncalcareous Mesozoic strata. Source bedrock is relatively uniform and its chemical and textural characteristics are transmitted to the colluvium. Colluvium B occurrences are restricted to the Subalpine

and Alpine Ecoregions. However, in the Lower Subalpine, colluvial landforms are occasionally admixtures of Colluvium B and Colluvium A. This is because some slopes in the Main Ranges, where Precambrian Miette Group slates and shales are capped by Gog Group quartzites, have colluvium compromised of debris falling from both groups. Colluvium intermediate in composition between Colluvium B and Colluvium C occurs when it is comprised of admixtures of slaty and carbonate or calcareous clastic strata which occur occasionally in the Front Ranges subprovince where calcareous strata adjoin or overlie the noncalcareous Mesozoic or Miette Group strata because of faulting.

Surface Expression and Modifying Processes

Colluvial slopes consisting of Colluvium B commonly occur as blankets and veneers overlying inclined bedrock on steep valley walls and as aprons along slope bases at major slope breaks and below steep rock walls. Exposed bedrock forms the subdominant portion of some colluvial slopes. Surface form is controlled by depth of deposition and by the underlying bedrock. Colluvium B landforms commonly have long, linear, inclined slopes ranging from 45 to 100%. Colluvium B slopes with complex topography have linear slopes whose continuity is broken by one or more steep bedrock escarpments.

Soil creep is a common surface modification affecting landforms comprised of Colluvium B. Soil creep indicates active colluviation affecting surface layers but its effects on surface form and genetic material characteristics are negligible. Effects on soil development, however, are significant.

Snow avalanching is characteristic of some colluvial slopes. Varying amounts of material are deposited downslope during avalanche events, therefore its effects on genetic material and associated soils are variable. Its effects on surface form are virtually negligible, however, its effects on vegetation are great. Avalanche related fluvial activity is important to material accumulation on aprons below channelled tracks and couloirs. Here fluvial material thinly mantles or becomes interbedded with colluvial material.

Other processes affecting Colluvium B include slope failure, surface sheet erosion, solifluction and cryoturbation. Slope failure encompasses slow mass movement, often rotational, of unconsolidated material plus partial failure of underlying bedrock downslope along a slip surface. Such failed slopes are postglacial and, in some instances may still be active. Surface sheet erosion occurs locally and affects the upper sola of soils. Solifluction and cryoturbation occur infrequently,the latter only in the Upper Subalpine and Alpine.

Textural Properties

Colluvium B is medium textured. The fine earths are generally comprised of 20 to 60% sand and 5 to 20% clay. This range falls within the silt loam, loam and sandy loam textural classes defined by C.S.S.C. (1978a). Textural variation among selected Bm, BC and C horizon samples is portrayed in Fig. 10. Increasing sand content accompanied by decreasing clay content corresponds to increased input of quartzite and sandstone from source areas above. Angular and thin, flat coarse fragments, dominantly slates and shales, commonly constitute 35% to 90%, and occasionally 100% by volume, of Colluvium B. Coarse fragment content usually increases with depth. Quartzites occasionally mix with Miette Group slates and shales when capped by Gog Group strata. Carbonate fragments also occur occasionally.

Colluvium B and C have similar textures and are differentiated by chemical properties. Colluvium B and A have similar chemical properties but are distinguished by textural differences. Accessory features, including coarse fragments, soil development, and location, are necessary to differentiate phases of Colluvium B and A with similar textures (e.g. 50 - 70% sand range) Colluvium B usually has a high content of coarse fragments consisting primarily of slates or shales rather than quartzites as in Colluvium A. In particular, Colluvium B is not as stony as Colluvium A.

Soils developed in Colluvium B have thin sola and thin, weakly developed or absent eluvial Ae horizons whereas soils developed in Colluvium A have thick sola and thick, well developed Ae horizons.

Finally, Colluvium A, B and C are differentiated by the nature of the lithology of the bedrock outcrop from which the colluvium was derived. Colluvium B is situated on or below slopes comprised of noncalcareous slates and shales.

Calcareousness and Reaction Properties

Colluvium B is usually noncalcareous and acid, ranging from extremely acid to medium acid (C.S.S.C. 1978a) with pH values commonly ranging from 4.3 to 6.0. A low lime phase (<5% $CaCO_3$ equivalent) with higher pH (6.0 to 7.0) occurs locally but is characterized by soils with acidic (pH 5.5 or less) sola. This phase is attributed to a minor influence of calcareous beds in the strata from which the colluvium is derived.

Colluvium B and A have similar low lime and low pH properties whereas Colluvium C is usually chemically different, but can have similar low lime phases differentiated by associated soil development. Colluvium B, includ-

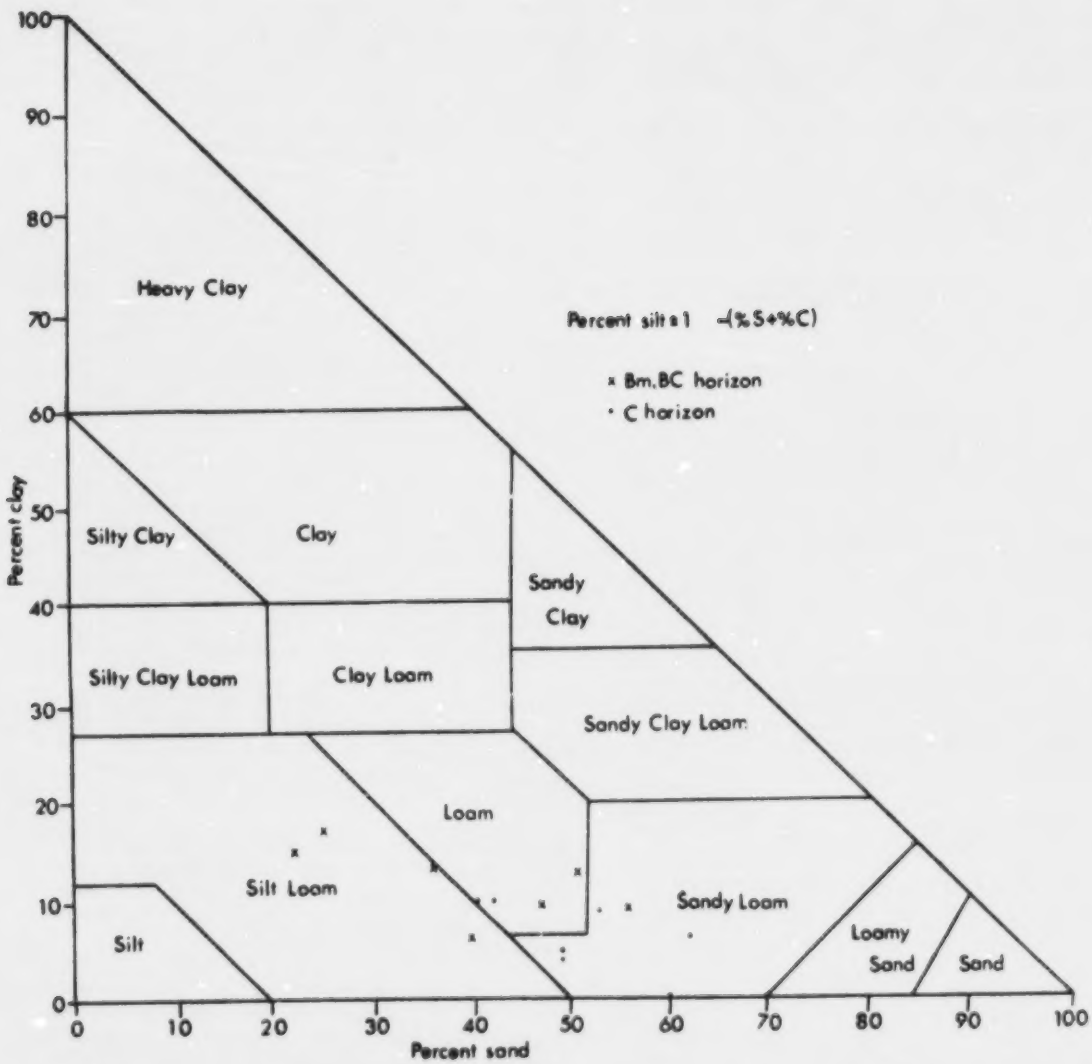


Figure 10 Textural variation among selected Bm, BC, and C horizon samples of noncalcareous, medium textured colluvium (Colluvium B).

ing its low lime phase, is dominated by soils with extremely to strongly acidic (pH 5.5 or less) sola including specifically, the B and underlying horizons to a thickness of 25 cm. Soils developed in the low lime phase of Colluvium C generally have medium acid to neutral (pH >5.5) lower sola.

Discussion

Colluvium B is noncalcareous and medium textured, being derived primarily from slaty and shaly bedrock. The Redoubt (RD) and Whitehorn (WH) Ecosections occur on colluvial slopes comprised of Colluvium B. The Fairview (FV) Ecosection occurs on colluvial slopes comprised of Colluvium B and/or Colluvium A.

Miscellaneous Landscapes Talus (T) and Colluvial Rubble (CR) consist of Colluvium B in areas dominated by Miette Group and noncalcareous Mesozoic strata, mainly slates and shales.

COLLUVIUM C

Concept and Distribution

Modally, Colluvium C is calcareous (neutral to alkaline), medium textured, colluvium derived from carbonate and calcareous clastic strata. These strata are common in both the Main and Front Ranges (Fig. 4).

Colluvium C is the most extensive of the three colluvial genetic materials because the

carbonate and calcareous clastic strata are most extensive, often overlying or interbedded with noncalcareous strata. Calcareous strata are abundant in all three Ecoregions of Banff and Jasper.

Surface Expression and Modifying Processes

Colluvial landforms consisting of Colluvium C commonly occur as blankets and veneers overlying inclined bedrock on steep valley walls and as aprons along slope bases at major slope breaks and below steep rock walls. Exposed bedrock forms the subdominant portion of some colluvial slopes. Surface form is controlled by thickness of deposition and by the underlying bedrock. Colluvium C landforms commonly have long, linear, inclined slopes ranging from 45 to 100%. Those landforms with complex topography have linear slopes whose continuity is broken by one or more exceptionally steep bedrock escarpments.

Soil creep is a common surface modification affecting landforms comprised of Colluvium C. Soil creep indicates active colluviation affecting surface layers but its effects on surface form and genetic material characteristics are negligible. Effects on soil development, however, are significant.

Snow avalanching is characteristic of some colluvial slopes. Varying amounts of material are deposited downslope during avalanche events therefore its effects on genetic material and associated soils are variable. Its effects on surface form are virtually negligible but its effects on vegetation are great. Avalanche related fluvial activity is important to material accumulation on aprons below channelled tracks and couloirs. Fluvial material thinly mantles or is interbedded with colluvial material.

Other processes affecting Colluvium C include slope failure, surface sheet erosion, solifluction and cryoturbation. Slope failure encompasses slow mass movement, often rotational, of unconsolidated material plus partial failure of underlying bedrock downslope along by a slip surface. Such failed slopes are postglacial and, in some cases may still be active. Surface sheet erosion occurs locally and affects the upper sola of soils. Solifluction and cryoturbation occur infrequently, the latter only in the Upper Subalpine and Alpine.

Textural Properties

Colluvium C is medium textured. The fine earths are generally comprised of 20 to 60% sand and 0 to 25% clay. This range falls within the silt loam, loam and sandy loam textural classes defined by C.S.S.C. (1978a). Textural variation among selected BC and C horizon samples of Colluvium C is portrayed in Fig. 11. Increasing sand content and decreasing clay content corresponds to increased input of quartzite and sandstone material from source areas above. Angular coarse fragments commonly constitute 35 to 90% and occasionally 100% by volume of Colluvium C. Coarse fragment content usually increases with depth. A high proportion are carbonate and calcareous clastic fragments.

Calcareousness and Reaction Properties

Colluvium C is strongly to extremely calcareous and neutral to mildly alkaline in reaction. Calcium carbonate equivalent content commonly ranges from 30 to 95%; pH values from 7.0 to 7.8. A low lime phase with carbonate content ranging from 1 to 15% is important in some areas where noncalcareous clastic strata are extensive. The most extensive areas of low lime colluvium occurs in the Front Ranges of eastern Banff and Jasper.

The low lime phase of Colluvium C is distinguishable from the low lime phases of Colluvium A and B by its reaction and by the soils that develop on it. The reaction (pH 6.8 to 7.8) of the low lime phase of Colluvium C remains comparable to that of modal Colluvium C. Colluvium C, including its low lime phase, is dominated by soils with medium acid to neutral (pH >5.5) lower sola including specifically, the B and underlying horizons to a thickness of 25 cm. This is in contrast to soils developed in the low lime phases of Colluvium A and B which have extremely to strongly acidic (pH 5.5 or less) sola. Overall, Colluvium C soils are characterized by thin sola and weakly to moderately developed B horizons rather than having thicker sola and Ae horizons as in Colluvium A and B. Occasionally, Colluvium C has advanced soils with strongly developed B horizons occurring in a thin, altered, medium textured, eolian material (Eolian material B) veneer.

Discussion

Colluvium C is calcareous and medium textured, being derived primarily from carbonate and calcareous clastic strata. It is the most extensive of the three colluvial genetic materials differentiated in Banff and Jasper. The Bow Summit (BS), Sawback (SB) and Wildflower (WF) Ecosections occur on colluvial landforms consisting of Colluvium C. Low lime phases of Colluvium C occur in the Sawback 5 (SB5) and Wildflower 7 (WF7) Ecosites.

A dark colored phase of Colluvium C is common in eastern regions of both parks. Its color (dark browns and grays to black) is attributed to incorporation of material from carbonaceous Mesozoic strata. The normal color of Colluvium C is much lighter and ranges through the browns and yellowish browns to gray browns and grays.

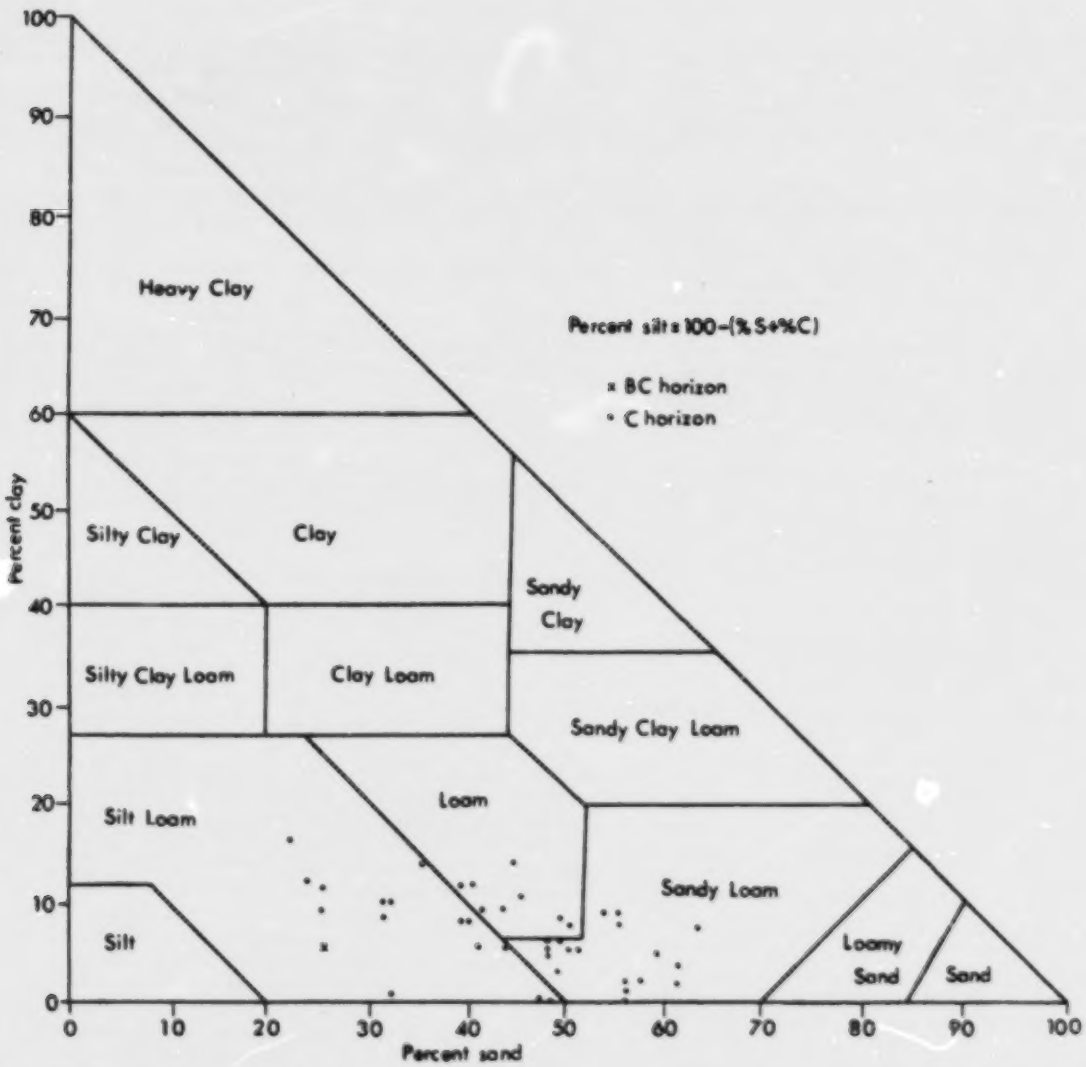


Figure 11 Textural variation among selected BC, and C horizon samples of calcareous, medium textured colluvium (Colluvium C).

Miscellaneous Landscapes Talus (T) and Colluvial Rubble (CR) consist of Colluvium C in areas dominated by carbonate and calcareous clastic strata.

MORAINAL GENETIC MATERIAL

Morainal material (till) is defined as unsorted and unstratified drift deposited by and underneath a glacier without subsequent reworking by glacial meltwater (Gary et al. 1972). Glaciation was a major factor in shaping the landscape of Banff and Jasper National Parks; hence, morainal deposits occur extensively. Till is occasionally intimately associated with ice contact stratified drift. Both are collectively considered glacial deposits as opposed to the proglacial materials, such as glaciofluvial and glaciolacustrine.

Morainal topography frequently dominates valley walls, broad valley floor benchlands, cirque basins, cols, and shoulders, even though veneers of other genetic materials often thinly mantle the till. Till thickness is variable, generally increasing downslope, with the thickest deposits occurring at the lowest elevations, except on benchlands where depths are highly variable. Surface form most often reflects bedrock control; hence, morainal blankets and veneers overlying inclined, hummocky, and ridged bedrock are abundant. On broad benchlands, surface form also directly reflects deposition and includes both hummocky and ridged moraine. Slope failure is a postglacial

process that often produces hummocky surfaces. Morainal landform slopes commonly range from 5 to 70%.

Three, and possibly up to five, major Pleistocene glacial advances and readvances occurred in the main valleys of the Canadian Rocky Mountains (Stalker 1963, 1969, McPherson 1970, Harris and Boydell 1972, Rutter 1972, Shaw 1972, Fox 1974, Roed 1975). There is some evidence to suggest the last deglaciation of major valleys in Banff and Jasper occurred 9000 to 9500 years B.P. (Westgate and Dreimanis 1967, Rutter 1972, Roed 1975). Recent moraines occur near the numerous glaciers and icefields presently existing in the Main Ranges geologic subprovince, particularly near the Continental Divide. These were deposited during and after the Neoglacial maximum, thought to be early to mid-nineteenth century (Heusser 1956, Gardner 1972, Kucera 1972).

Textural and chemical characteristics of morainal material do not reflect glacial chronology. Source bedrock lithology is more important (Rutter 1972, Stalker 1973). Lithologic properties were imparted by the various strata and were admixed by glaciation. However, mixing was not so complete as to have created homogeneous morainal material. Therefore, continua of textural (from coarse to fine) and chemical (from noncalcareous and acidic to highly calcareous and alkaline) properties exist in the tills of Banff and Jasper. The continua are broken and organized to identify, for the purposes of this Ecological Land Classification, three till genetic material units (Table 6). Separation is based on textural and calcareousness properties that can be traced to three major groups of bedrock lithology. The three till parent materials are: (1) noncalcareous, coarse textured till (Till A) derived from medium to coarse grained, noncalcareous, clastic strata; (2) noncalcareous, medium textured till (Till B) derived from medium to fine grained, noncalcareous clastic strata; and (3) calcareous, medium textured till (Till C) derived from medium to fine grained, carbonate and calcareous clastic strata.

TILL A

Concept and Distribution

Modally, Till A is noncalcareous (acidic), coarse textured, glacial till derived from medium to coarse grained, noncalcareous clastic bedrock, mainly quartzite. Its major source is the Lower Cambrian Gog Group (quartzite) that dominates portions of the Main Ranges geologic subprovince (Fig. 4). Local occurrences are correlated to the Mount Wilson Formation (e.g. near Pipestone Pass warden cabin in Banff) and quartz sandstone layers of the Permian-Pennsylvanian Rocky Mountain Group (north of Cascade Mtn. in Banff).

Till A is the least extensive of the three till genetic material units. The structural style of the Main Ranges—Gog Group quartzites underlain by Precambrian Miette Group slates and shales and capped by younger carbonate strata—favors admixtures of till derived from contrasting bedrock sources. Hence, Till A does not often extend great distances beyond quartzitic source areas, unless morainal material from other sources has not been introduced from tributary valleys and valley walls. For these reasons, Till A occurrences are restricted to the Subalpine and Alpine Ecoregions. It is not known to occur in the Montane.

Surface Expression and Modifying Processes

Moraines consisting of Till A commonly occur as blankets overlying inclined bedrock on valley walls, blankets and veneers overlying ridged and hummocky bedrock on higher elevation shoulders, cirque basins, and cols. Its existence on low elevation benchlands in major valleys is very limited. Thick moraines with hummocky surfaces, produced directly by deposition (e.g. old rock glaciers) and occasionally by post glacial slope failure, occur sporadically. Ridged moraine, reflecting deposition rather than underlying bedrock surfaces, includes local features such as lateral and terminal moraines. Slopes on Till A moraines commonly range from 5 to 70%.

Slope failure, gullying, and avalanching are common surface modifications affecting moraines comprised of Till A. Slope failure is of two types, the most common encompassing old (inactive) rock glaciers that originated as talus and protalus ramparts below rock walls. In some cases, these have introduced Till A, derived from hanging cirques and rock walls, to downslope positions dominated by other till parent materials. The second, less common type of slope failure encompasses slow mass movement, often rotational, of till or till plus underlying bedrock downslope, guided by a slip surface. Such failed slopes are postglacial and, in some instances, may still be active.

Gullies are steep-sided narrow, subparallel ravines produced by fluvial erosion, mainly intermittent streams created by concentration of surface runoff from feral slopes above. Gullied moraine is most common on linear valley walls below hanging cirques and steep rock and colluvial (feral) slopes that act as the source (fetch) areas for the incising streams. Some ridged and hummocky terrain in cirques and cols is dissected by a few, nonparallel gullies associated with intermittent and permanent streams. Process status may be active or inactive.

Although snow avalanching is common, its effects on moraine surface form, parent material, and associated soils are virtually negligible. Effects on vegetation, however, are great. Other modifying processes have limited impact. Surface sheet erosion occurs locally and affects upper sola of soils. Occasional patches of lag stones and boulders are manifestations of historic surface erosion. Shallow surface colluviation also occurs locally on steep moraines and affects soil sola. These two processes are particularly abundant on avalanched localities and burned areas. Solifluction and cryoturbation occur infrequently in the Upper Subalpine and Alpine.

Textural Properties

Till A is coarse textured, referring to both the fine earth fraction and volume of coarse fragments. The fine earths are generally comprised of 60 to 85% sand and 0 to 10% clay. This range falls within the sandy loam and loamy sand textural classes defined by C.S.S.C. (1978a). Textural variation among selected BC and C horizon samples of Till A is portrayed in Fig. 12. Increasing clay content accompanied by decreasing sand content corresponds to increased input of finer grained material from source areas. In many instances, Till A tends to become slightly finer textured with increasing depth. Rounded and subrounded coarse fragments, dominantly quartzite, commonly constitute 35 to 70% by volume of Till A.

Tills A and C are differentiated by textural and chemical properties; Tills A and B pri-

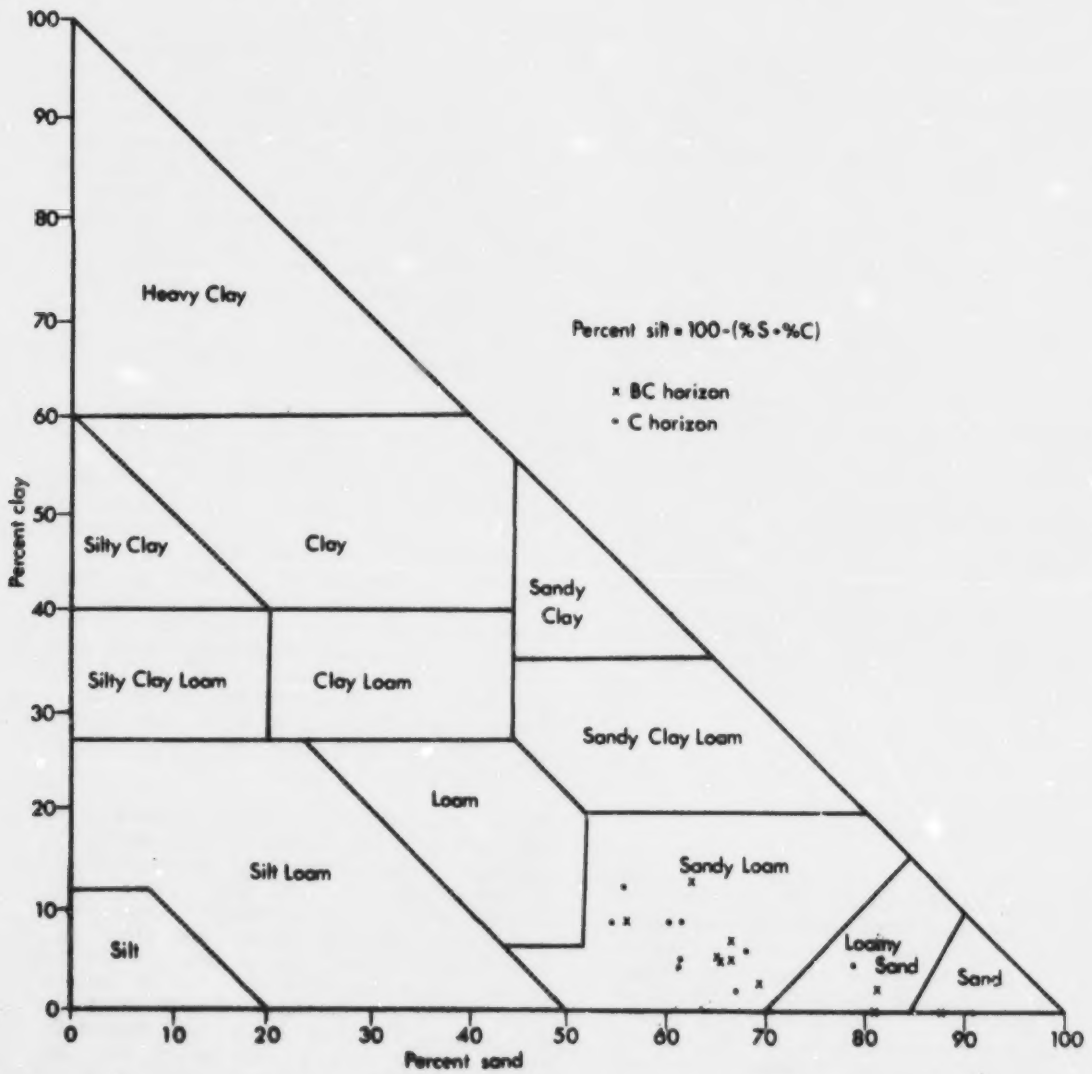


Figure 12 Textural variation of selected BC and C horizon samples of coarse textured, noncalcareous till (Till A).

marily by textural properties. Accessory characteristics, including coarse fragments, thickness and degree of soil development and location, are necessary to differentiate phases of Tills A and B that have similar textures (e.g. in the 50-70% sand range). Till A has the highest content of coarse fragments, most of which are quartzitic. Shale, slate, or carbonate fragments are rare or absent. Stones and boulders are especially abundant in Till A, its morainal surfaces often being quite stony.

Soils developed on Till A are distinctive. They usually have deeply developed sola and thick, well developed eluvial (Ae) horizons, features indicative of the rapidly pervious, noncalcareous, coarse textured genetic material. Their BC or lower B horizons are often weakly cemented (duric tendencies). Soils developed in Till B and C genetic materials have thin sola with thin to absent Ae horizons. Where the Ae horizons are developed in veneers of altered, medium textured eolian material (Eolian material B), Ae horizon thickness is not a useful criterion for separating Tills A, B, and C.

Finally, Tills A, B, and C are differentiated by the nature of the lithology of the bedrock from which the till was derived as inferred from the location of the respective moraines.

Calcareousness and Reaction Properties

Till A is usually noncalcareous and acidic, with pH values of about 4.3 to 6.0. A low lime phase (<15% $CaCO_3$ equivalent) with higher pH (6.0 to 7.0) occurs locally but is overlain by deeply weathered, acidic soils. The increased pH is attributed to added carbonates through groundwater discharge or the incorporation of small amounts of calcareous material in the derivation of the till.

The low lime phase of Till A is similar to the low lime phase of Till C. These low lime phases usually can be distinguished by textural properties and by associated soil development. Till A (including its low lime phase) can be distinguished by deeply developed soils with extremely to strongly acidic (pH 5.5 or less) sola including the B and underlying horizons to a thickness of 25 cm. Soils developed in the low lime phase of Till C generally have medium acid to neutral (pH >5.5) lower sola.

Discussion

Till A is noncalcareous and coarse textured, being derived primarily from quartzitic bedrock. It is least extensive of the three till genetic material units differentiated in Banff and Jasper. The Eiffel (EF), Moraine Lake (ML), and Larch Valley (LV) Ecosections occur on moraines consisting of Till A. It is a minor constituent of the Cavell 1 (CA1), Consolation Valley 1 (CV1), and Egypt 3 (EG3) Ecosites.

Till A and coarse textured ice contact stratified drift (Ice Contact Stratified Drift A) are intimately associated in some areas, having shared depositional environments and source lithology. The most notable example of this association is in the Blue Creek area in Jasper.

TILL B

Concept and Distribution

Modally, Till B is noncalcareous (acidic), medium textured, glacial till derived from medium to fine grained, noncalcareous, clastic bedrock, mainly shale and slate. Its major source is the Precambrian Miette Group (slate and shale) that dominates portions of the Main Ranges geologic subprovince (Fig. 4). Till B also occurs, but less extensively, in the Front Ranges geologic subprovince. Source strata in these eastern areas are the noncalcareous, often carbonaceous, Jurassic and Lower Cretaceous strata of the Kootenay, Nikanassin, and Luscar Formations and the Fernie Group. Till derived from these Mesozoic sources is darker colored (dark browns and grays to black) than till derived from the older strata (yellowish browns and browns).

Till B is more extensive than Till A. Till B extends some distance beyond the several small, but distinctive, source areas characterized by subdued mountain landscape formed entirely in the recessive Miette Group and noncalcareous Mesozoic strata. Source bedrock in this situation is relatively uniform and its characteristics are transmitted to the till. However, introduction of material derived from other sources in tributary valleys and on valley walls tends to alter the till characteristics. Tills derived from admixtures of slaty and quartzitic sources occur most often in the Main Ranges subprovince where the Gog Group strata conformably overlie the Miette Group strata. Till B occurs infrequently at low elevations and is confined to chiefly the Subalpine and Alpine Ecoregions.

Surface Expression and Modifying Processes

Morainal landforms consisting of Till B commonly occur as blankets overlying inclined bedrock on valley walls, blankets and veneers overlying ridged and hummocky bedrock on benchlands, shoulders, cirque basins, and cols. Thick moraines with hummocky surfaces, produced directly by deposition (e.g. old rock glaciers) and occasionally by postglacial slope failure, occur sporadically. Ridged morainal landforms reflecting deposition include local features such as lateral and terminal moraines. Slopes on Till B moraines commonly range from 5 to 70%.

Slope failure, solifluction, and avalanching are common surface modifications sometimes affecting landforms comprised of Till B. Slope failure is of two types. The most common, encompassing old (inactive) rock glaciers, have sometimes introduced Till B, derived from shoulders and cols, to downslope positions dominated by other till units. An example occurs in the upper Red Earth Creek valley in Banff where hummocky moraine consisting of Till B derived from the Gibbon Pass area was superimposed on the linear north wall of the valley. Morainal blankets and veneers consisting of Till C mantle this same wall up and down-valley beyond the limits of the old rock glacier. The second type of slope failure is less common and encompasses slow mass movement, often rotational, of till or till plus underlying bedrock downslope along a slip surface. Such failed slopes are postglacial and, in some instances may still be active.

Solifluction, the slow mass flow downslope of saturated material (Washburn 1973), is most active at high elevations under moderately well to poorly drained conditions with episodic seepage. Movement is probably greatest in the spring when meltwater is abundant and soils are still partially frozen. Cryoturbation is an associated process occurring sporadically in the high elevation areas. Both are most abundant in eastern Banff and Jasper on till derived from Mesozoic strata. Neither significantly affect textural and chemical properties of the till, except for partial sorting. Landform surface expression, however, may be subtly altered by the occurrence of solifluction lobes, benches, and streams (Washburn 1973) on a small scale and solifluction sheets over expansive areas. Circles, nets and micro-hummocks are manifestations of cryoturbation. Both processes significantly affect soil development.

Although snow avalanching is common, its effects on moraine surface forms, parent material, and associated soils are virtually negligible. Effects on vegetation, however, are great.

Gullies, including the few isolated nonparallel ravines associated with well established, intermittent and permanent streams, occur infrequently on Till B moraines. On Till A or C moraines, gullies are abundant. This anomolous phenomenon is explained, in large part, by surrounding landscape features. Till B moraines often occupy high elevation subdued landscape, consequently, the fetch area for collecting surface runoff does not exist. Till B moraines on valley walls are often bounded above by well defined shoulders that intercept concentrated runoff from adjoining feral slopes.

Other modifying processes have limited impact. Surface sheet erosion occurs locally and affects upper sola of soils. Shallow surface colluviation also occurs locally on steep moraine and affects soil sola. These two processes are particularly abundant on avalanched localities and burned areas.

Textural Properties

Till B is medium textured in terms of both the fine earth fraction and volume of coarse fragments. The fine earths are generally comprised of 30 to 60% sand and 5 to 25% clay. This range falls within the silt loam, loam, and sandy loam textural classes defined by C.S.S.C. (1978a). Textural variation among selected BC and C horizon samples of Till B is portrayed in Fig. 13. Increasing sand content accompanied by decreasing clay content corresponds to an increased component of quartzite and sandstone material from source areas. Subrounded and thin, flat coarse fragments commonly constitute 20 to 50%, by volume, of Till B.

Tills B and A are distinguished by textural differences. When the texture is comprised of 50 to 70% sand, accessory features such as coarse fragments, soil development, and location, are necessary to differentiate moraines into Till A or Till B. Till B is not as stony as Till A and the coarse fragments are mainly slates or shales.

Soils developed on Till B have thin sola and thin, weakly developed or absent eluvial (Ae) horizons. Soils developed on Till A have thick sola and thick, well developed Ae horizons. Where the Ae horizons are developed in veneers of altered medium textured eolian material (Eolian material B), Ae horizon thickness is not a useful criterion for seperating Tills A, B, and C.

Finally, Tills A, B, and C are differentiated on the nature of the lithology of the bedrock from which each was derived, as inferred from the location of the respective moraines.

Calcareousness and Reaction Properties

Till B is usually noncalcareous and acid with pH values of about 4.3 to 6.0. A low lime phase (<5% $CaCO_3$ equivalent) with higher pH (6.0 to 7.0) occurs locally but has soils with acidic (pH 5.5 or less) sola. This phase is attributed to carbonate additions through groundwater discharge or the incorporation of some calcareous material in the derivation of the tills.

The low lime phase of Till B is similar to the low lime phase of Till C. The low lime phase of Till B is usually dominated by soils with extremely to strongly acidic (pH 5.5 or less) sola including the B and underlying horizons to a thickness of 25 cm. Soils developed in the low lime phase of Till C generally have

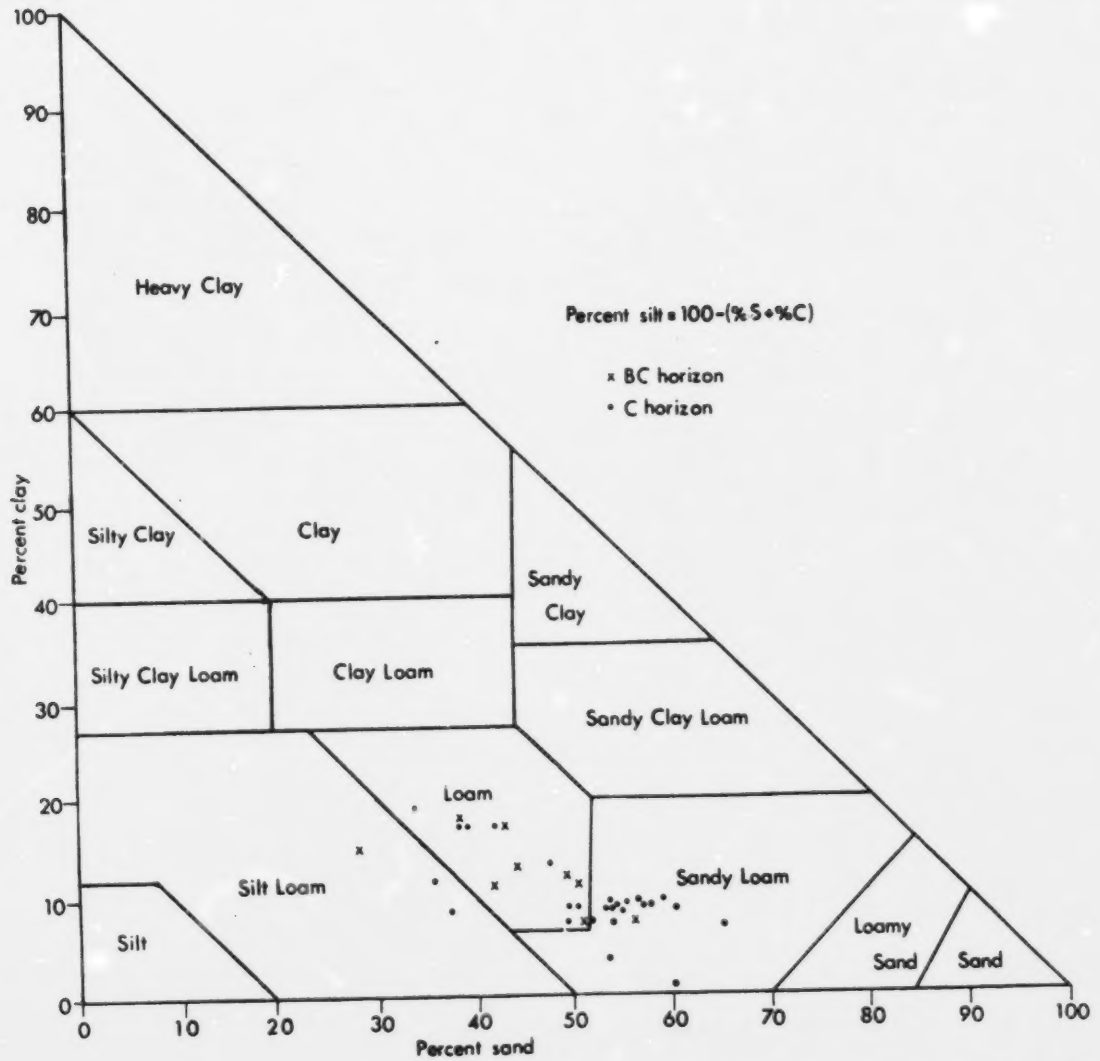


Figure 13 Textural variation of selected BC and C horizon samples of the medium textured, noncalcareous till (Till B).

medium acid to neutral (pH >5.5) lower sola.

Discussion

Till B is noncalcareous and medium textured, being derived primarily from slaty and shaly bedrock. The Cavell (CA), Egypt (EG), and Jonas (JN) Ecosections occur on moraines comprised of Till B. Moraines comprising the Sphinx 1 and 2 (SX1, SX2) Ecosites consist predominantly of Till B. Tills B and C are codominant in the moraines forming the Consolation Valley 1 (CV1) and Sphinx 3 (SX3) Ecosites. The dark colored phase of Till B, derived from the noncalcareous Mesozoic shales is subdominant in moraines forming the Tyrrell (TR) and Snowflake (SF) Ecosections. This same phase is a minor constituent of the Goat 2 (GT2) Ecosite.

Till B and the medium-stratified phase of Ice Contact Stratified Drift A, also derived from slates and shales, are intimately associated in a few areas such as the upper Miette River valley in Jasper and the Eisenhower Junction area in Banff.

TILL C

Concept and Distribution

Modally, Till C is calcareous (neutral to alkaline), medium textured glacial till derived from carbonate and calcareous clastic strata.

These strata are common in both the Main and Front Ranges subprovinces (Fig. 4).

Till C is the most extensive of the three till parent materials because the carbonate and calcareous clastic strata are most extensive, often capping or intercalating with noncalcareous strata. Additionally, only small amounts of calcareous rock material are necessary to produce Till C. It is abundant in all three Ecoregions.

Surface Expression and Modifying Processes

Moraines consisting of Till C commonly occur as blankets overlying inclined bedrock of valley walls, blankets and veneers overlying ridged and hummocky bedrock on benchlands, shoulders, cirque basins and cols. Thick moraines with hummocky surfaces, produced directly by deposition (e.g. old rock glaciers) and by postglacial slope failure, occur sporadically. Ridged moraine, reflecting deposition as opposed to control by underlying bedrock surfaces, includes local features such as lateral and terminal moraines and more expansive areas such as the fluted ground moraine in the Bow River valley near Baker Creek (Rutter 1972). Limited areas of inclined moraine occur along creek and river channels. These are short, linear, erosional slopes created by the down- and side-cutting action of present and historical streams through the glacial deposits of valley floor benchlands and valley walls. Slopes on Till C moraines commonly range from 5 to 70%. Slopes <5% occur locally on some benchlands and have an undulating surface expression.

Slope failure, gullying, solifluction, and avalanching are common surface modifications affecting moraines comprised of Till C. Slope failure is of two types. The first encompasses inactive rock glaciers that originated as talus and protalus ramparts below rock walls. In some cases, these have introduced Till C, derived from hanging cirques and rock walls, to downslope positions dominated by other till parent materials. The second type encompasses slow, often rotational, downslope mass movement of till or till plus underlying bedrock along a slip surface. Such failed slopes are postglacial and in some instances may still be active.

Gullies are steep-sided, narrow, subparallel ravines produced by fluvial erosion. This erosion is mainly by intermittent streams created by concentration of surface runoff from feral slopes above. Gullied morainal landforms are most common on linear valley walls below hanging cirques, and steep rock and colluvial (feral) slopes that act as the source (fetch) areas for the incising streams. Some ridged and hummocky terrain in cirques and cols is dissected by a few nonparallel gullies associated with intermittent and permanent streams. Process status may be active or inactive.

Solifluction, the slow mass flow downslope of saturated material (Washburn 1973), is most active at high elevations under moderately well to poorly drained conditions with episodic seepage. Movement is probably greatest in the spring when meltwater is abundant and soils are still partially frozen. Cryoturbation is an associated process occurring sporadically in high elevation areas. Both are most abundant in eastern Banff and Jasper on till derived from Mesozoic strata. Neither significantly affect textural and chemical properties of the till, except for partial sorting. Landform surface expression, however, may be subtly altered by the occurrence of solifluction lobes, benches, and streams (Washburn 1973) on a small scale although solifluction sheets can occur over expansive areas. Circles, nets, and microhummocks are manifestations of cryoturbation. Both processes significantly affect soil development.

Although snow avalanching is common, its effects on moraine surface form, genetic material, and associated soils are virtually negligible. Effects on vegetation, however, are great. Other modifying processes have limited impact. Surface sheet erosion and shallow surface colluviation are important on some of the steepest morainal slopes, especially if burned or avalanched. These two processes affect soil development.

Textural Properties

Till C is medium textured, in terms of both the fine earth fraction and volume of coarse fragments. The fine earths are generally comprised of 20 to 60% sand and 5 to 27% clay. This range falls within the silt loam, loam, and sandy loam textural classes defined by C.S.S.C. (1978a). Textural variation among selected C horizon samples of Till C is portrayed in Fig. 14. Increasing sand content, accompanied by decreasing clay content, corresponds to increased input of quartzite and sandstone material from source areas. A coarse textured phase (<70% sand), with a higher than normal content of medium and coarse grained clastics, occurs sporadically. A fine textured phase, higher than normal in silt and clay content, is of local importance in the Main Ranges subprovince. It is probably derived from argillaceous limestone strata. Rounded, subrounded, and thin, flat coarse fragments commonly constitute 20 to 50%, by volume, of Till C. A high proportion are carbonate and calcareous clastic fragments.

Calcareousness and Reaction Properties

Till C is calcareous and neutral to mildly alkaline in reaction. Calcium carbonate equivalent content commonly ranges from 15 to 85%, pH values from 7.0 to 7.8. Till C with pH >7.8 and lime content >85% is rare. However, a low lime phase, with car-

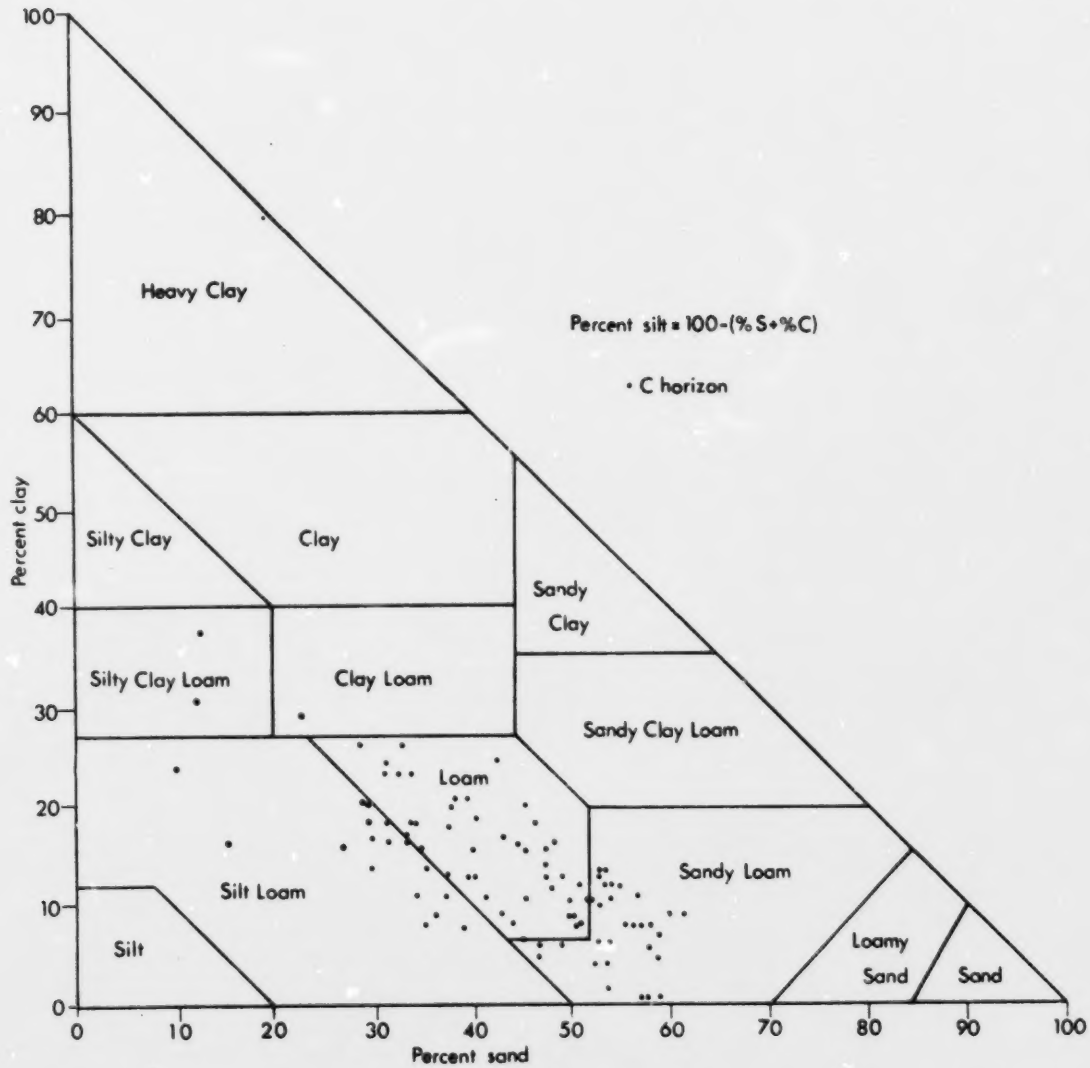


Figure 14 Textural variation of selected C horizon samples of calcareous, medium textured till (Till C).

bonate content ranging from 1 to 15%, is important in some areas where noncalcareous clastic strata are extensive. The most extensive example of low lime till occurs in the middle Athabasca and lower Miette River valleys upstream from Jasper townsite where it is underlain by the dominantly noncalcareous strata comprising the Miette Group. Additionally, it is dominant or codominant on morainal landforms forming the Panorama Ridge 3 (PR3) and Consolation Valley 1 (CV1) Ecosites.

Till C's low lime phase is distinguishable from the low lime phases of Tills A and B by its reaction and by the soils that develop on it. Even though containing low amounts of carbonate, the reaction of the low lime phase remains comparable (with pH values of 6.8 to 7.8) to that of normal Till C (neutral to mildly alkaline). Till C, including its low lime phase, is dominated by soils with medium acid to neutral (pH >5.5) lower sola including the B and underlying horizons to a thickness of 25 cm. Soils developed in the low lime phases of Tills A and B have extremely to strongly acidic sola (pH 5.5 or less). Overall, Till C soils are characterized by thin sola and a variety of B horizons, depending on mesoclimatic and surficial veneer influences.

Discussion

Till C is calcareous and medium textured, being derived primarily from carbonate and calcareous clastic strata. It is the most extensive of the three tills differentiated in

Banff and Jasper. The Goat (GT), Molar Pass (MP), Peyto Lake (PL), Patricia (PT), and Warwick (WW) Ecosections occur on moraines consisting of Till C. The Baker Creek 1 (BK1), Bryant 1 and 2 (BY1, BY2), Norquay 1 (NY1), and Panorama Ridge 1, 2, and 3 (PR1, PR2, PR3) Ecosites occur on moraines consisting of Till C. Calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) often shares contiguous glacial landforms with Till C on valley floors and benchlands. Consequently, both form the landforms of the Baker Creek 6 (BK6), Norquay 3 (NY3), and Panorama Ridge 4 (PR4) Ecosites. Till C, comprised predominantly of material derived from Mesozoic strata, dominates the Tyrrell (TR) and Snowflake (SF) Ecosections. Tills C and B are codominant in the moraines forming the Consolation Valley 1 (CV1) and Sphinx 3 (SX3) Ecosites. Till C is the subdominant genetic material unit of the landforms of the Sphinx 2 (SX2) Ecosite and is a minor constituent of the landforms of the Sphinx (SX1) Ecosite.

A dark colored phase of Till C is common in eastern regions of both Banff and Jasper. Its color (dark browns and grays to black) is attributed to incorporation of material from carbonaceous Mesozoic strata. Till C is normallly much lighter in color and ranges through the browns and yellowish browns to gray browns and grays.

Recent moraines, including the Miscellaneous Landscape M and the Warwick (WW) Ecosection, consist primarily of Till C. Existing glaciers are associated with the upper stratigraphic column of the Main Ranges subprovince. Their Neoglacial moraines are derived from the calcareous strata forming this column.

ICE CONTACT STRATIFIED GENETIC MATERIAL

Ice contact stratified drift is partially sorted material deposited by glacier ice but with concomitant and subsequent reworking, locally, by flowing and ponded glacial meltwater. The result is extreme vertical and lateral textural variability over short distances, except where coarse to medium grained source strata preclude the incorporation of abundant clay and silt sized particles. In essence, ice contact stratified drift encompasses an intimate, random mixture of morainal, glaciofluvial, and occasionally, glaciolacustrine sediments individually inseparable at a scale of 1:50,000. Unsorted, unstratified morainal material (till) is occasionally intimately associated with ice contact stratified drift, both are collectively considered glacial deposits as opposed to the proglacial materials, glaciofluvial and glaciolacustrine. Glaciofluvial terraces often adjoin ice contact stratified deposits and form adjacent landscape downslope on valley floors. Glaciolacustrine veneers often overlie ice contact stratified deposits.

Ice contact stratified drift forms moraine-like landforms near valley floors, on valley floor benchlands, and, occasionally, on lower valley wall slopes. This genetic material is most abundant in the lower reaches of valley systems, particularly of broader valleys, and hence is most extensive in the Montane and Lower Subalpine. Distribution is limited in the Upper Subalpine, very limited in the Alpine.

Hummocky, ridged, and inclined surface expressions are typical of ice contacted stratified deposits. Hummocky surfaces are most often of depositional origin, ridged surfaces may reflect underlying bedrock or depositional features. Outstanding depositional features include kettles, kames, and eskers. Differential erosion by ice margin streams has also contributed to irregular surface forms. Two types of inclined surfaces occur. Deposits on lower valley wall slopes are depositional with linear (straight), inclined surfaces reflecting underlying bedrock. Occasionally on this physiographic position, hummocky depositional surfaces are superimposed upon the inclined bedrock surfaces. The second type is erosional, encompassing the short stream bank scarps created by the down and sidecutting action of present and historical streams.

The most important modifying processes are channelling (Eroded modifier, C.S.S.C. 1978b) and gullying. These have resulted in differential erosion and, in the case of ice marginal channels, have contributed significantly to the irregular (ridged and hummocky) surface expressions. Failed slopes occur occasionally and also influence surface form. Other modifying processes, which influence primarily soil and vegetation development, include snow avalanching, sheet erosion, and soil creep. In some areas, ice contact stratified drift deposits are thinly mantled by other genetic materials, namely eolian, fluviolacustrine, glaciolacustrine, and organic.

Derivation of ice contact stratified deposits is associated with Pleistocene glaciation (Stalker 1963, 1969, McPherson 1970, Harris and Boydell 1972, Rutter 1972, Shaw 1972, Fox 1974, Roed 1975). Textural qualities are attributable, in part, to source bedrock lithology and, in part, to reworking of the glacial deposits by glacial meltwater. Calcareousness and reaction properties reflect source bedrock lithology. Two ice contact stratified units are identified in the Banff-Jasper Ecological Land Classification report. Separation is based primarily on chemical properties, secondarily on textural charcteristics, both reflecting different bedrock sources. The two units are: (1) noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A) de-

rived primarily from medium to coarse grained, noncalcareous clastic strata ,and (2) calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) derived from medium to fine grained, calcareous clastic and carbonate strata.

ICE CONTACT STRATIFIED DRIFT A

Concept and Distribution

Modally, Ice Contact Stratified Drift A is noncalcareous (acidic), coarse textured, glacial drift that is derived from medium to coarse grained, noncalcareous clastic bedrock and has been partially reworked by flowing glacial meltwater. Its major source is the lower Cambrian Gog Group (quartzite) that dominates portions of the Main Ranges geologic subprovince. Ice Contact Stratified Drift A generally grades, upslope, into unsorted, unstratified, noncalcareous, coarse textured till (Till A).

Ice Contact Stratified Drift A is the least extensive of the two ice contact stratified units and occurs primarily in the Subalpine Ecoregion. The type area is the Blue Creek valley in northern Jasper where the unit dominates the valley floor benchlands and lower slopes. This valley is geologically dominated by the McNaughton Formation, a subdivision of the Gog Group. In a few areas the textural influence of medium to fine grained, noncalcareous, clastic bedrock (Miette Group slate and shale) is evident, the derivative being a variably textured variant of Ice Contact Stratified Drift A. This variant is of limited areal extent. Major known occurrences are located in the upper Miette River valley, in the Astoria River valley below Mt. Edith Cavell, and in the Bow River valley between Vermilion Pass and Eisenhower Junction. The last occurrence is described by Rutter (1972) as an ice contact fluvial complex featuring abandoned side glacial stream channels. The variably textured variant generally grades, upslope, into unsorted, unstratified, noncalcareous, medium textured till (Till B).

Surface Expression and Modifying Processes

Glacial landforms comprised of Ice Contact Stratified Drift A commonly exhibit hummocky and ridged surface expressions. These surfaces reflect deposition, localized bedrock control, and differential erosion by ice marginal streams. Slopes are complex and commonly range from 5 to 45%. Inclined surfaces are not common. In some areas, this hummocky and ridged terrain is bounded below by terraces consisting of noncalcareous, coarse textured glaciofluvial material (Glaciofluvial material A).

Channelling (Eroded modifier, C.S.S.C. 1978b) is the most important process that has affected landforms composed of Ice Contact Stratified Drift A. Ice marginal channels are common and contribute to slope complexity. The channels are randomly distributed, sinuous, and generally converge downvalley, emptying onto valley floors. Process status is considered inactive although some channels contain modern, intermittent streams. Several channels have been eroded deep enough to expose local water tables. High water tables plus stream activity have resulted in wetland localities contained in channel depressions between ridges and hummocks.

Textural Properties

Ice Contact Stratified Drift A is coarse textured, being comprised of about 60 to 100% sand, 0 to 10% clay, and 5 to 70% rounded to subrounded coarse fragments dominated by quartzites. Low silt and clay contents reflect the coarse to medium grained, source bedrock. The fine earth range falls within the sandy loam, loamy sand, and sand textural classes defined by C.S.S.C. (1978a). It is based on a very few analyzed samples, therefore was established by combining the modal textural ranges of noncalcareous, coarse textured till (Till A) plus noncalcareous, coarse textured glaciofluvial material (Glaciofluvial material A). Conceptually, Ice Contact Stratified Drift A is an intimate complex of these two genetic materials. Glaciolaucstrine sediment is a rare constituent. Vertical stratification occurs but is rather subtle. Lateral textural variability over short distances is greater than in the vertical direction but not to the extent that typifies calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B).

The variably textured variant of Ice Contact Stratified Drift A has the same textural variability as Ice Contact Stratified Drift B. Its major source is medium to fine grained, noncalcareous, clastic bedrock, namely the Miette Group. Hence, the glacial derivatives are generally medium textured (silt loam, loam, and sandy loam, like Till B) but locally reworked by flowing and ponded glacial meltwater creating coarse textured (sandy loam to sand) and fine textured (silty clay loam and silty clay) layers and pockets. Coarse fragment content in this variant ranges from 5 to 70% by volume.

Calcareousness and Reaction Properties

Modally, Ice Contact Stratified Drift A is noncalcareous and acid. There are insufficient analytical data to establish reaction class and pH ranges, therefore the ranges for noncalcareous, coarse textured till (Till A) are assumed to apply. These are extremely to medium acid with pH values of about 4.3 to 6.0. Small amounts of lime (<15% $CaCO_3$ equivalent) accompanied by higher pH (6.0 to 7.0) may occur at depth in some localities

(e.g. Athabasca River valley downstream from the Chaba River confluence). The soils, however, are deeply weathered with thick eluvial (Ae) horizons and have extremely to strongly acidic (pH 5.5 or less) sola including, specifically, the B and underlying horizons to a thickness of 25 cm.

Discussion

Ice Contact Stratified Drift A is derived primarily from quartzitic bedrock and is the least extensive of the two ice contact stratified material units. The Azure 1 (AZ1) and Topaz 2 (TZ2) Ecosites occur on glacial landforms comprised of Ice Contact Stratified Drift A. This material and noncalcareous, coarse textured glaciofluvial material (Glaciofluvial material A) are codominant in the Topaz 1 (TZ1) Ecosite. The variably textured variant of Ice Contact Stratified Drift A is an accessory geomorphic feature of the Cavell 1 (CA1) Ecosite. Both the modal and variant forms occur as accessory features of the Consolation Valley 1 (CV1) Ecosite. Minor occurrences of Ice Contact Stratified Drift A may be found in other Ecosites such as Cavell 2 and 4 (CA2, CA4), Larch Valley 3 (LV3), Moraine Lake 1 and 2 (ML1, ML2), and Sphinx 2 (SX2).

ICE CONTACT STRATIFIED DRIFT B

Concept and Distribution

Modally, Ice Contact Stratified Drift B is noncalcareous (neutral to alkaline), variably textured, glacial drift that is derived from medium to fine grained, calcareous clastic and carbonate bedrock and has been partially reworked by flowing and ponded glacial meltwater. Plate 4 shows an Ice Contact Stratified Drift B deposit in section located near the Mistaya Canyon bridge in Banff.

Ice Contact Stratified Drift B is the most extensive of the two ice contact stratified units and occurs primarily in the Subalpine and Montane Ecoregions. It is most often in the lower reaches of valley systems, particularly of broad valleys. It forms moraine-like landforms near valley floors, on valley floor benchlands, and, occasionally, on lower valley wall slopes.

Surface Expression and Modifying Processes

Glacial landforms comprised of Ice Contact Stratified Drift B commonly exhibit hummocky, ridged, and inclined surface expressions. Slopes are complex and simple and range from 5 to 70%. Hummocky surfaces are most often of depositional origin, but occasionally reflect bedrock control. Ridged surfaces may reflect underlying bedrock or depositional features. Outstanding depositional features include kettles, kames, and eskers. Differential erosion also contributes to irregular surface forms. Ice marginal channels are common in some localities. Small terraces occur occasionally.

Two types of inclined surfaces occur. Deposits on lower valley wall slopes are depositional, often with linear, inclined surfaces reflecting underlying bedrock. In some cases on this physiographic position, hummocky depositional surfaces occur on inclined bedrock surfaces. The second type is erosional and encompasses the short, sinuous, stream bank scarps created by the down- and sidecutting action of present and historical streams through glacial deposits that mantled valley floors.

Channelling (Eroded modifier, C.S.S.C. 1978b) and gullying are the most important processes that have affected landforms composed of Ice Contact Stratified Drift B. Ice marginal channels are common in a few localities and contribute to slope complexity. The channels are randomly distributed, sinuous, and generally converge downvalley, emptying onto valley floors. Process status is considered inactive although some channels contain modern, intermittent streams. These erosional features are not as common and extensive as on landforms of Ice Contact Stratified Drift A but, like those in the noncalcareous counterpart, some contain wetlands. Subparallel gullies oriented perpendicular to the contour characterize many of the more steeply sloping inclined surfaces, particularly the stream bank scarps. Process status may be active or inactive. Failed slopes occur occasionally and contribute to hummocky surface expressions.

Other modifying processes, which influence primarily soil and vegetation, include snow avalanching at higher elevations on valley walls and sheet erosion or soil creep on the steepest slopes. In some areas, other depositional processes have operated subsequent to glacial deposition, thereby creating eolian, fluviolacustrine, glaciolacustrine, and organic blankets and veneers that mantle the Ice Contact Stratified Drift B deposits. Of note are calcareous, medium textured eolian material (Eolian material A) mantling the landscape in the lower Athabasca and North Saskatchewan/Howse River valleys and calcareous, fine textured glaciolacustrine material (Glaciolacustrine material) occurring in pockets in the lower Spray, Mistaya, Rocky, and Snake Indian River valleys. Ice Contact Stratified Drift B generally grades, upslope, into unsorted, unstratified, calcareous, medium textured till (Till C), deposited as part of the same glacial event. In several areas, the hummocky and ridged terrain of Ice Contact Stratified Drift B is bounded below (downslope) by terraces consisting of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B).

Textural Properties

Ice Contact Stratified Drift B is variably textured. Extreme vertical and lateral textural variability over short distances is characteristic and attributable to its polygenetic depositional environments. The material originated as medium textured (silt loam, loam, and sandy loam, like Till C) glacial detritus derived from medium to fine grained strata. Local reworking by flowing glacial meltwater created coarse textured (sandy loam to sand) layers and pockets. Less often, silt- and clay-laden meltwater was locally ponded creating fine textured (silty clay loam and silty clay) layers and pockets. The overall result is a wide range in fine earth composition with sand content ranging from 0 to 100%, clay content from 0 to 50 or 60%. Rounded and subrounded coarse fragments also show vertical and lateral stratification and constitute 5 to 70%, by volume, of Ice Contact Stratified Drift B.

Calcareousness and Reaction Properties

Ice Contact Stratified Drift is strongly to extremely calcareous and neutral to mildly alkaline in reaction. Calcium carbonate equivalent content commonly ranges from 15 to 85%, pH values from 7.0 to 7.8. pH values >7.8 or lime content >85% are rare. However, a low lime phase, with carbonate content ranging from 1 to 15% and pH values from about 6.8 to 7.8, is important in some areas where noncalcareous clastic strata occur extensively. The area of note encompasses the middle Athabasca and lower Miette River valleys upstream from Jasper townsite. In this area, the low lime phases of Ice Contact Stratified Drift B and Till C are underlain by Miette Group strata.

The soils developed in Ice Contact Stratified Drift B, including the low lime phase, have thinner sola and higher reaction than those developed in Ice Contact Stratified Drift A. Soils developed in the calcareous material generally have medium acid to neutral (pH >5.5) lower sola including, specifically, the B horizon and underlying horizons to a thickness of 25 cm.

Discussion

Ice Contact Stratified Drift B is derived primarily from calcareous clastic and carbonate bedrock and is the most extensive of the two ice contact stratified material units. No Ecosection separations are based on this geomorphic unit in the Banff-Jasper Ecological Land Classification. Rather, it was included with Ecosections characterized by Till C moraines because the two geomorphic units are often intimately associated and form contiguous landscape, having shared glacial events. More importantly, they have similar surface expressions and are associated with similar soils and vegetation. However, Ice Contact Stratified Drift B is recognized at the Ecosite level in the taxonomy. The Baker Creek 4 (BK4), Bryant 4 (BY4), Norquay 3 (NY3) and Panorama Ridge 6 (PR6) Ecosites are dominated by glacial landforms consisting of Ice Contact Stratified Drift B. In the Baker Creek 6 (BK6), Panorama Ridge 4 (PR4), and Talbot 3 (TA3) Ecosites, this unit is codominant with Till C. Glacial materials of TA3 are overlain by blankets and veneers of calcareous, medium textured eolian material (Eolian material A). Ice Contact Stratified Drift B is an important accessory feature of the Goat 2 (GT2), Patricia 1, 3, 4, and 5 (PT1, PT3, PT4, PT5), and Consolation Valley 1 (CV1) Ecosites. Limited occurrences may be found in other Ecosites.

GLACIOFLUVIAL GENETIC MATERIAL

Glaciofluvial genetic material in Banff and Jasper is the deposit generated by flowing water whose volume and sediment load are principally controlled by melting glacier ice. These deposits have largely ceased aggrading with the retreat of the glacier, but some near present ice fronts are still actively aggrading. This usage differs from C.S.S.C. (1978b) in that herein glaciofluvial material is regarded as essentially proglacial. Material with similar characteristics, but having irregular surfaces and local extent indicating direct contact with glacier ice is considered part of ice contact stratified genetic material.

Glaciofluvial material originates from abnormally high flow rates in a watershed as generated by release of water stored in ablating icefields. Large volumes of melting ice are needed to produce a deposit of any extent. Deposition occurs where this meltwater encounters a valley floor with gentle grade. The resulting sediment overload is rapidly deposited, especially the coarser bedload, producing massive bedding. Much of the silt and clay fraction either remains in suspension or is easily eroded again, especially if it is not stabilized by vegetation. Thus, the resulting deposit is high in coarse fragment content and coarse textured. Diurnal fluctuation in flow during summer melting is also important to rapid aggradation, as daily falling water levels also produce sediment overload. Smith (1972) discusses some of these processes presently occurring at the confluence of the Alexandra and North Saskatchewan Rivers in Banff. Glaciofluvial material grades into fluvial material with increasing distance from the glacier as flow fluctuations and sediment load are less influenced by the melting ice. In these situations, sediment more typically is stratified and aggrades much less rapidly. Lakes within a river system often act as a buffer, separating glaciofluvial at the head from fluvial at the mouth (e.g. Peyto Lake). South of Saskatchewan Crossing, Banff pre-

sently has and probably historically had more attenuation of glaciofluvial conditions by lakes than Jasper and northern Banff. Portions of the Athabasca and North Saskatchewan drainages emanating from the Columbia and proximal icefields impart glaciofluvial-like characteristics to these rivers throughout their course in the parks, as no lakes buffer the flow and sediment load. In contrast, the Bow and Mistaya Rivers in Banff are fluvial systems despite the amount of ice feeding them, a result of loss of sediment to and flow regulation by lakes on tributaries and along their courses.

A different magnitude of activity is evident in the soils and especially vegetation between recent, well drained fluvial and glaciofluvial systems. On actively aggrading fluvial landforms, deposition is frequent enough to hold soil development to a minimum (e.g. Regosols, weakly developed Brunisols), while vegetation is often at climax (e.g. spruce forest). This indicates activity within the order of 10^2 yrs. On actively aggrading glaciofluvial landforms, Regosolic soils are the rule, but in this case vegetation is also held to incipient stages (e.g. herb mat, shrub thicket). This indicates activity within the order of $\leq 10^1$ yr. A trimline-like effect, particularly marked with trees, at the boundaries of presently active glaciofluvial areas is a distinctive trait usually not evident on active fluvial areas (Plate 5).

Glaciofluvial deposits are distributed throughout the parks on valley floors and lower benchlands, locations that generally occur in broad valleys. The frequency of occurrence and extent of deposits decrease with increasing elevation because the volume of ice up valley diminishes as the glacier terminus recedes upward. Source area becomes increasingly restricted with increasing elevation as well. Since the present ecological zonation is also elevationally influenced, a lesser percentage of each Ecoregion is occupied by glaciofluvial material from Montane to Alpine respectively.

The influence of source diversity and glacial contribution to stream deposits is evident from calcareousness properties of sediments from the present and ancestral Athabasca Rivers. In the vicinity of Jasper townsite, our samples from the glaciofluvial terraces are approximately 20% $CaCO_3$ equivalent, while sediment in the present stream bed is about 60%. This occurs despite the greater textural maturity of the more recent deposits. Reference to the geological map of Price and Mountjoy (1970a) indicates that the only extensive calcareous strata are at the extreme headwaters of this river and some of its tributaries, locations that also currently support icefields. Therefore a majority of sediment in the present Athabasca River must be derived from the very restricted occurrence of calcareous strata, probably through the agent of ice, and carried to its present location by meltwater. The sediment from the ancestral river shows a carbonate content more in keeping with the proportion of calcareous and noncalcareous bedrock in the drainage, indicating wider ice activity on diverse sources when material in the terraces was deposited by a closer ice front.

Glaciofluvial materials are marginally younger than, and often overlie, till and ice contact deposits of the same glacier, exposed during retreat. Highest terrace levels in an area are composed of the oldest glaciofluvial materials and formed closest to the retreating ice. Subsequent underfit streams incise into this unconsolidated material, generating terraces embracing a new valley flat having dimensions commensurate with the lesser flow. Glaciofluvial material often is buried by more recent fluvial material, especially on present fluvial fans. Eolian material in various thicknesses overlies most glaciofluvial material except in northern Jasper.

As previously discussed, coarse textures are chiefly governed by the depositional environment. However, a continuum of chemical properties from noncalcareous, acid, to highly calcareous, alkaline exist. For purposes of this Ecological Land Classification, this continuum was broken into two genetic material units. These are Glaciofluvial material A (essentially noncalcareous) and Glaciofluvial material B (calcareous), with characteristics as discussed below.

GLACIOFLUVIAL MATERIAL A

Concept and Distribution

Glaciofluvial material A is noncalcareous, coarse textured material deposited by glacial meltwater. It reflects almost exclusively noncalcareous original bedrock source strata, but is usually derived from a reworking of noncalcareous glacial till.

Glaciofluvial material A is absent from the Montane because the diversity of bedrock in the source area always includes calcareous strata. Lower Subalpine and Upper Subalpine occurrences are restricted to valleys in the Main Ranges which, especially around the glacier head, have walls made up of the Gog and/or Miette Groups. Glaciofluvial material A is therefore less extensive than Glaciofluvial material B, its calcareous counterpart.

Surface Expression and Modifying Processes

Terrace is the most common surface expression of Glaciofluvial material A. Slopes are complex, but a majority of any surface is made up of linear terrace treads with <5%

slope. Short risers between terrace levels are steeper, with slopes from 30 to 70%.

Evidence of abandoned channels (Eroded modifier, C.S.S.C. 1978b) is often present on the terrace treads, but these do not significantly affect material properties. Eolian veneers frequently mantle glaciofluvial deposits except in northern Jasper, resulting in medium textures in the upper sola developed on these landforms.

Textural Properties

Textures of Glaciofluvial material A are coarse, being strongly controlled by the high energy glacial meltwater which acted as a depositional agent. Also, materials derived from Gog Group strata are inherently low in clay. Sand is usually >60%, while clay is seldom >5%. These values fall within part of the sandy loam, loamy sand, and sand classes of C.S.S.C. (1978a). Bedding is often massive, but where stratification occurs textures fall within the coarse category.

The coarse fragment content range is 35 to 70% by volume, mainly subrounded gravels and cobbles. Surfaces are frequently very stony (C.S.S.C. 1978a), particularly in the absence of an eolian surface veneer. Some surfaces are lower in coarse fragments, indicating a waning stage of glaciofluvial activity, probably at some distance from the ice front.

Calcareousness and Reaction Properties

Glaciofluvial material A is usually noncalcareous, hence acid, ranging from extremely to medium acid (C.S.S.C. 1978a) with pH values 4.3 to 6.0. Where calcareous materials start to impart Glaciofluvial material B characteristics, separation of these materials is based on pH of the sola developed on them. Specifically Glaciofluvial material A produces sola with pH ≤5.5 to a depth of 25 cm below the top of the B horizon. This includes low lime glaciofluvial material with up to about 10% $CaCO_3$ equivalent. No presently active glaciofluvial material is Glaciofluvial material A because $CaCO_3$ equivalents are much greater than 10%.

Discussion

Glaciofluvial material A is less extensive than Glaciofluvial material B, its calcareous counterpart, and is a common constituent of the Topaz 1 (TZ1) Ecosite and plays a minor role in Topaz 2 (TZ2) and Azure 1 (AZ1). Locally, it may resemble ice contact stratified material, but in the latter, a landform encompassing a variety of materials, surfaces are irregular. Fluvial material is coarse textured and stratified, with a wider range of coarse fragment content than Glaciofluvial Material A.

GLACIOFLUVIAL MATERIAL B

Concept and Distribution

Glaciofluvial material B is calcareous, coarse textured material deposited by glacial meltwater. It reflects the presence of some calcareous strata in the original bedrock source, but is usually derived from a reworking of calcareous glacial till.

Glaciofluvial material B is distributed throughout the parks, because of the extent of calcareous sources and the small content of lime needed to make a sediment calcareous. It is the only glaciofluvial material occurring in the Front Ranges. It occurs in both stable and presently aggrading forms. All presently active glaciofluvial material is calcareous because icefields and large glaciers presently occur on calcareous bedrock of the upper stratigraphic column of the Main Ranges (refer to Glacier (GL) Miscellaneous Landscape).

Surface Expression and Modifying Processes

Terrace is the most common surface expression of stable Glaciofluvial material B. Slopes are complex, but a majority of any surface is made up of linear terrace treads with <5% slope. Short risers between terrace levels are steeper, with slopes from 30 to 70%. Active Glaciofluvial material B has both level and fan surface expressions that will be maintained until a decrease in flow occurs. These areas, with slopes <5%, are analagous to and probably in future will become terrace treads.

Evidence of abandoned channels (Eroded modifier, C.S.S.C. 1978b) is often present, but these do not significantly affect material properties. Eolian veneers frequently mantle stable glaciofluvial deposits except in northern Jasper, resulting in medium textures in the upper sola developed on these landforms.

Textural Properties

Textures of Glaciofluvial material B are coarse, being strongly controlled by the high energy glacial meltwater which acted as a depositional agent. Sand is usually >60%, while clay is seldom >5%. These values fall within part of the sandy loam, loamy sand, and sand classes of C.S.S.C. (1978a). Bedding is often massive, but where stratification occurs textures fall within the coarse category. Fig. 15 illustrates textural variation of selected C horizons of all pedons sampled on Glaciofluvial material B.

Coarse fragment content range is 35 to 70% by volume, mainly subrounded gravels and cobbles. Surfaces are frequently very stony (C.S.S.C. 1978a), particularly in the absence

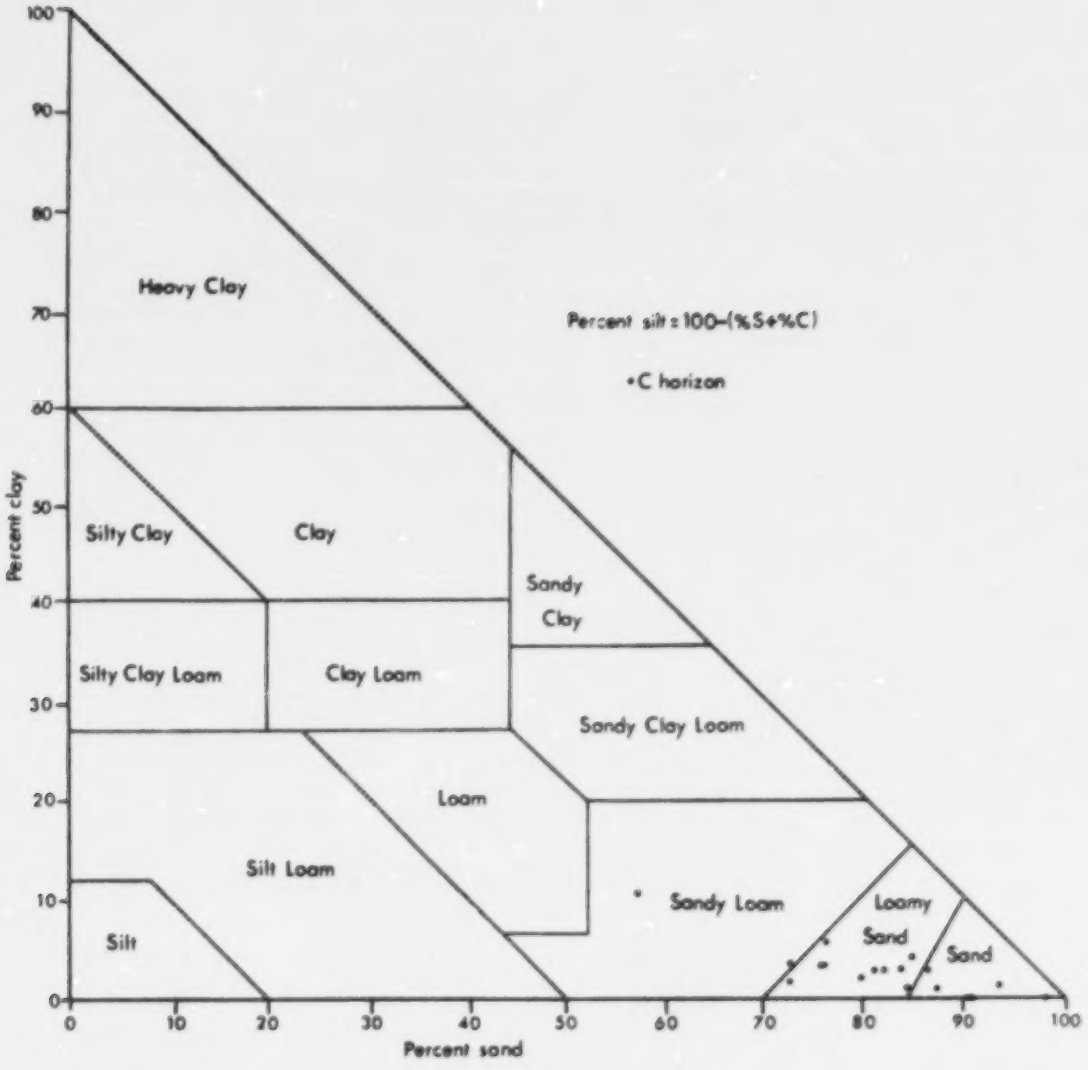


Figure 15 Textural variation among selected C horizons of all pedons sampled on calcareous, coarse textured glaciofluvial material (Glaciofluvial material B).

of an eolian surface veneer. Some surfaces are lower in coarse fragments, indicating a waning stage of glaciofluvial activity, probably at some distance from the ice front.

Calcareousness and Reaction Properties

Glaciofluvial material B is calcareous, hence neutral to moderately alkaline in reaction with pH values 7.0 to 8.0. Where low lime calcareous material with characteristics close to those of Glaciofluvial material A occurs, separation is based on pH of the sola developed on them. Specifically, Glaciofluvial material B produces sola with pH >5.5 within a depth of 25 cm below the top of the B horizon. This occurs with up to approximately 10% $CaCO_3$ equivalent. All presently active glaciofluvial material with Regosolic soils is classed as Glaciofluvial material B because it invariably has >10% $CaCO_3$ equivalent.

Discussion

Glaciofluvial material B is more extensive than Glaciofluvial material A, its noncalcareous counterpart, and is the principal genetic material of the stream channel (SC) Miscellaneous Landscape and of the Athabasca (AT), Bow Valley (BV) and Nigel (NG) Ecosections. Locally, it may resemble ice contact stratified material, but in the latter, a landform encompassing various materials, sur-

faces are irregular and materials are of variable texture. Boulders, absent in Glaciofluvial material B are often present in gravelly ice contact stratified material. Fluvial material is coarse textured and stratified, with a wider range of coarse fragment content.

FLUVIAL GENETIC MATERIAL

Fluvial (alluvial) material encompasses sediment deposited primarily by nonglacial flowing water. The distinction between glacial and nonglacial flow regimes is rather vague, particularly in a historical sense. Thus, it is quite possible that present fluvial landscape originated in glaciofluvial environments that changed over time, by glacial retreat and accompanying stream channel and sediment load alteration, to fluvial systems. Some stream floodplains (e.g. the lower Athabasca River valley floor in eastern Jasper), although mapped as fluvial landscape, are still aggrading, the sediment being transported primarily by glacial meltwater. These fluvial-glacial sediments are often interbedded with and locally supplanted by calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) on floodplains. Fitting neither the fluvial nor lacustrine definitions (C.S.S.C. 1978b), these fluviolacustrine deposits share the floodplain depositional environment, being restricted to ponded backwater localities that were or are episodically inundated by slowly moving, nearly stagnant, silt-laden waters. The toes of many fans and aprons are thinly mantled by altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) derived by sheet erosion and washing of upslope sediments.

Fluvial landscape is most abundant along valley floors including benchlands. Two distinct surface form groups, both with linear (simple) slopes, are characteristic. Level plains (floodplains), with slopes ranging from 0 to 2%, contain the major streams that formed them. Fans and aprons occur on gentle slopes along the toes of steeper slopes from which their sediments originated. These are especially extensive below gullied moraine and avalanched slopes on valley walls. Surface slopes of fans and aprons are generally concave and range from 2 to 45%. The steepest segments include the apexes, the gentlest slopes occur at the toes. Fluvial materials also exist as veneers and blankets in some cirque basin, col, shoulder, and valley floor localities. Here surface expressions reflect those of underlying material and may be irregular (complex). Weakly expressed terracing (risers <1 m) occurs on some fluvial floodplains.

The causes of stream deposition are similar on all fluvial landforms and involve the loss of transporting power resulting from a decrease in stream velocity. This is produced by a decrease in stream gradient, an increase in spread of stream waters, obstructions to flow, and a decrease in water volume (Thornbury 1954).

Patterns of deposition differ slightly on floodplain versus fan and apron forms. Stream braiding and meandering distribute sediment on level floodplains. Thornbury (1954), Leopold et al. (1964), and Smith (1972) discuss depositional processes and features on floodplains. These are shared by glaciofluvial flow regimes and include deposition of the finer textured fluviolacustrine materials of backwater reaches. Fluvial fan and apron development involves two contrasting processes. Construction by distributary streams, with most deposition occurring in and beside the migrating channels (washes) during flood episodes, is common (Engeln 1942, Thornbury 1954, McPherson and Hirst 1972, Roed and Wasylyk 1973). Mudflows are also important to varying degrees in fan and apron construction (Leopold et al. 1964, Winder 1965, McPherson and Hirst 1972, Owens 1972, Russell 1972, Roed and Wasylyk 1973). An example of recent mudflow activity occurred in the Bow River valley near Hector Lake in late August of 1977. Debris, accumulated in stream channels on the slopes below Mt. Hector, was dumped onto Highway 93.

Textural qualities differ somewhat between water course and mudflow deposition. Deposits associated with stream channel sedimentation are moderately to well sorted, vertically stratified, and variable across the landscape. The fine earth fraction commonly contains 15 to 90% sand and 0 to 25% clay; uniformity is present only as thin, randomly distributed layers and lenses. Rounded and subrounded coarse fragments, predominantly of gravel size, are distributed in like manner and range from 0 to 70%, by volume, of fluvial deposits. Thus, for convenience, fluvial materials are considered to be coarse textured and stratified. Amounts and grain size distribution of material transported to aggrading fluvial landscape are controlled by stream velocity, sediment load, and bedload. These are greatest during flood episodes, particularly following spring melt. Distribution of these sediments across fluvial landcape is controlled, in part, by local water velocity. The coarsest material, transported as bedload, gradually fills the channels; the finer material is deposited between channels during bank overflow. Over time the channel positions shift, thereby creating stratified deposits. Additionally, fans and aprons built by stream channel sedimentation tend to be coarser textured at their apexes than along their toes (Thornbury 1954, McPherson and Hirst 1972).

Mudflow deposits of fluvial fans and aprons are poorly sorted and uniformly textured with little or no stratification (Winder 1965, Roed and Wasylyk 1973). Coarse fragments range from gravels to boulders (Winder 1965) with

varying degrees of roundness. Thus, mudflow deposits are similar to their source materials whereas stream channel sediments do not resemble, texturally, source materials.

Linear (regular) slopes of many fluvial landforms are subtly broken by active and abandoned channels (Eroded modifier, C.S.S.C. 1978b). These are usually bounded by natural levees constructed by bank overflow during flood episodes. Textures of levee material, on existing surfaces, are generally intermediate between the coarse textured channels and the finer textured interchannel localities.

Fluvial landscape probably began developing immediately following glacial retreat, hence the speculation that the initial landforms are of glaciofluvial origin. Dating of buried volcanic ash layers (McPherson and Hirst 1972, Smith 1972, Roed and Wasylyk 1973) and observations on soil development in fluvial deposits indicate that ages of present fluvial surfaces and aggradation rates over time are highly variable. The youngest surfaces lack incised, well defined, stream channels, having instead several, shallow, often poorly defined distributary or braided channels that are level with or slightly higher than surrounding fluvial landscape (McPherson and Hirst 1972). These actively aggrading surfaces range in size from narrow strips adjacent to streams to domination of entire fluvial landforms. Soils associated with active aggradation are Regosolic and have poorly developed or absent surface organic layers.

Inactive fluvial surfaces are defined by Roed and Wasylyk (1973) as having well incised stream channels. Soil development on the surfaces surrounding the channels indicate relative age. Recent surfaces have Regosolic soils with thin surface accumulations of organic material. Older surfaces (i.e. 10^3 years and more), have B horizon development. However, cataclysmic fluvial deposition is unpredictable and can interupt the development of established soil horizons. The same age variability applies to fluvial landforms comprised predominantly of mudflow debris.

Fluvial landforms in Banff and Jasper are derived from diverse areas encompassing several other unconsolidated mineral genetic materials and various bedrock strata. As previously discussed, textures are mainly governed by depositional processes, but a continuum of chemical properties from noncalcareous, acid to highly calcareous, alkaline exists. For the purposes of Ecological Land Classification, this continuum was divided and organized to identify two fluvial material units. These are: noncalcareous, coarse, stratified fluvial material (Fluvial material A), derived from noncalcareous, unconsolidated mineral materials and noncalcareous bedrock; and calcareous, coarse, stratified fluvial material (Fluvial material B), derived from calcareous, unconsolidated, mineral materials and calcareous bedrock.

FLUVIAL MATERIAL A

Concept and Distribution

Modally, Fluvial material A is noncalcareous (acidic), coarse textured and stratified sediment deposited primarily by nonglacial flowing water and derived from noncalcareous, unconsolidated and consolidated materials. It is the least extensive of the two fluvial units because the noncalcareous source materials are less extensive than their calcareous counterparts. Distribution is greatest in the Main Ranges subprovince in areas dominated by Miette and Gog Group strata. Physiographic position (valley floors) within the Main Ranges structural setting places most occurrences in the Lower Subalpine portion of the Subalpine Ecoregion. Fluvial material A also occurs locally in areas dominated by Mesozoic strata. Sporadic Upper Subalpine and Alpine occurrences are related to subdued mountain topography (Mesozoic and Precambrian strata). Fluvial material A occurrences are very limited in the Montane Ecoregion.

Surface Expression and Modifying Processes

Fans and aprons are the most common surface expressions of Fluvial material A. These are generally concave and range from 2 to 45% slope. Level floodplain occurrences are limited, but dominate a few tracts. Veneers and blankets also occur occasionally, usually overlying morainal landforms.

Active and abandoned channels plus their natural levees are the most common modifying features. Avalanching and, at high elevations, solifluction occur but their effects on landform are negligible.

Textural Properties

Fluvial material A textures conform to the range (15-90% sand, 0-25% clay, 0-70% coarse fragments by volume) defined for the fluvial genetic material class discussed above. Water course deposits are stratified, mudflow deposits are not, unless considered as single layers within a polygenetic fluvial landform. In several instances, slates and shales dominate the coarse fragment fraction, particularly of mudflow layers derived from noncalcareous, medium textured till (Till B) or noncalcareous, medium textured colluvium (Colluvium B) sources.

Calcareousness and Reaction Properties

Fluvial material A is usually noncalcareous and acid, ranging from extremely to medium acid (C.S.S.C. 1978a) with pH values of about 4.3 to 6.0. Considering the diversity of source materials imparting characteristics to

any one fluvial landform, weakly calcareous mixtures (1-5% CaCO3 equivalent, pH 6.0-7.0) of Fluvial material A and calcareous, coarse, stratified fluvial material (Fluvial material B) are common. In some cases (e.g. Louise Creek fan) Fluvial materials A and B are interbedded, with Fluvial material A tending to dominate the present surface. Soil development is considered, where necessary, to separate weakly calcareous mixtures into Fluvial material A or B for mapping purposes, (i.e. Verdant (VD) versus Altrude (AL) Ecosections). Fluvial material A, including its low lime phase, is dominated by soils with extremely to strongly acidic (pH 5.5 or less) sola including, specifically, the B and underlying horizons to a thickness of 25 cm. Soils developed in the low lime phase of Fluvial material B generally have medium acid to neutral (pH >5.5) lower sola, provided pedogenic horizonation has occurred.

Discussion

Noncalcareous, coarse, stratified fluvial material (Fluvial material A) is the least extensive of the two fluvial material units. It dominates the fluvial landforms of the Verdant (VD) Ecosection and some tracts of the Cyclone 1 (CN1), Hector 1 (HC1), Hector 4 (HC4), Mosquito 1 (MQ1), Katherine 1 (KA1), and Num-Ti-Jah 2 (NT2) Ecosites. It is a minor constituent of the Hillsdale 1 (HD1) and Hillsdale 3 (HD3) Ecosites.

Thin veneers of altered medium textured eolian material (Eolian material B) and altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) occasionally overlie Fluvial material A. At low elevations (e.g. the Lower Subalpine) Regosolic soils are not abundant on this geomorphic unit. At higher elevations, they occur and are associated with recent aggradation or modifying processes such as solifluction. A dark colored phase, attributed to incorporation of carbonaceous Mesozoic material, occurs in eastern areas.

FLUVIAL MATERIAL B

Concept and Distribution

Modally, Fluvial material B is calcareous (neutral to mildly alkaline), coarse textured and stratified sediment deposited primarily by nonglacial flowing water and derived from calcareous, unconsolidated and consolidated materials. It is the most extensive of the two fluvial units because the calcareous source materials are more extensive than their noncalcareous counterparts. Also, only a small percentage of calcareous material within the sediment is necessary to produce Fluvial material B. It is common, primarily on valley floors and benchlands, throughout all areas and Ecoregions of Banff and Jasper. It is most extensive in the Montane and Lower Subalpine.

Surface Expression and Modifying Processes

Fans, aprons, and level floodplains are the most common surface expressions of Fluvial material B. Fans and aprons are generally concave from top to bottom and convex parallel to the slope and range from 2 to 45% slope. Level floodplains have linear slopes ranging from 0 to 2%. Veneers and blankets, usually overlying morainal landforms, also occur occasionally.

Active and abandoned channels plus their natural levees are the most common modifying features. Avalanching and, at high elevations, solifluction occur but their effects on landforms are negligible.

Textural Properties

Fluvial material A textures conform to the range (15-90% sand, 0-25% clay, 0-70% coarse fragments by volume) defined for the fluvial genetic material class discussed above. Water course deposits are stratified, mudflow deposits are not, unless considered as single layers within a polygenetic fluvial landform.

Calcareousness and Reaction Properties

Fluvial material B is usually calcareous and neutral to moderately alkaline in reaction. Calcium carbonate equivalent content commonly ranges from 5 to 85%, pH values from 7.0 to 8.0. Considering the diversity of source materials imparting characteristics to any one fluvial landform, weakly calcareous mixtures (1-5% $CaCO_3$ equivalent, pH 6.0-7.0) of Fluvial material B and noncalcareous, coarse, stratified fluvial material (Fluvial material A) are common. In some cases, the two genetic material units are interbedded. Soil development is considered, where necessary, to separate weakly calcareous mixtures into Fluvial material A or B for mapping purposes, (e.g. Altrude (AL) versus Verdant (VD) Ecosections). Fluvial material B, including its low lime phase, is dominated by soils with medium acid to neutral (pH >5.5) sola, including, specifically, the B and underlying horizons to a thickness of 25 cm. If Regosolic or wet soils are dominant, the distinction is not important. Soils developed in the low lime phase of Fluvial material A generally have extremely to strongly acidic (pH 5.5 or less) sola.

Discussion

Calcareous, coarse, stratified fluvial material (Fluvial material B) is the more extensive of the two fluvial genetic material units. It dominates the Altrude (AL), Hillsdale (HD) and Fireside (FR) Ecosections and the Pipestone 1, 2, 3, 6, and 7 (PP1, PP2, PP3, PP6, PP7) Ecosites. It is the most abundant and extensive constituent of the Cyclone 1 (CN1), Hector 1 (HC1), Hector 4 (HC4), Katherine 1 (KA1),

Mosquito 1 (MQ1), and Num-Ti-Jah 2 (NT2) Ecosites. Fluvial material B and calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) are co-dominant in the Vermilion Lakes 3, 4, and 5 (VL3, VL4, VL5) Ecosites. Fluviolacustrine material B often overlies, interbeds with, and locally supplants Fluvial material B on some floodplains. Altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) and, occasionally, altered medium textured eolian material (Eolian material B) thinly mantle Fluvial material B on some fans and aprons. Fluviolacustrine material A is especially common on toe positions. Calcareous, medium textured eolian material (Eolian material A), in some cases partially reworked by fluvial action, mantles some Fluvial material B landforms in the lower Athabasca River valley. A dark colored phase of Fluvial material B, attributed to incorporation of carbonaceous Mesozoic material, occurs in eastern regions of both parks.

FLUVIOLACUSTRINE GENETIC MATERIAL

Fluviolacustrine material encompasses relatively fine grained sediments deposited by slowly moving water, both glacial and nonglacial. Although defined as sediment deposited under alternating or overlapping fluvial and lacustrine conditions (Gary et al. 1972), floodplain fluviolacustrine deposits in Banff and Jasper are intimately associated with fluvial and glaciofluvial deposits and share their landforms. The second type is considered to be slope wash sediment. Consequently, fluviolacustrine material is considered to represent low energy deposition in fluvial systems.

By its textural characteristics, fluviolacustrine material does not fit the fluvial definition given by C.S.S.C. (1978b). It displays vertical and lateral textural variability and is only uniformly textured in thin layers and lenses. High contents of silt and/or clay are characteristic, hence this genetic material is conveniently labelled fine, stratified. Sand content commonly ranges from about 0 to 20%, clay content from 10 to 50%. This range includes all or parts of the silt, silt loam, silty clay loam, and silty clay textural classes as defined by C.S.S.C. (1978a). Coarse fragments are usually absent but may range to 5%.

The textural range of fluviolacustrine material overlaps that of glaciolacustrine material. Textural stratification and lateral variability is one feature differentiating fluviolacustrine sediment from the more uniform glaciolacustrine deposits. Secondly, fluviolacustrine material has a wide range of bulk density (0.7-1.9 g/cm^3 based on a few analyses) and shows massive structure. Glaciolacustrine material is typically dense with varving or pseudo subangular blocky structure. Thirdly, thin, fibrous, silt-and clay-laden, organic layers and pockets are common constituents of fluviolacustrine deposits, particularly on floodplains. Mineral plus organic stratification is rare in glaciolacustrine deposits. Surface form and geomorphic relationships constitute a fourth distinguishing feature.

Glaciolacustrine material occurs in former lake basins and mantles, as blankets and veneers, gently sloping glacial landforms of valley floor benchlands. Fluviolacustrine sediment occurs in two distinct geomorphic environments, neither recognizable as lake basins. The thickest deposits occur on present and former backwaters of valley floor floodplains where they overlie, interbed with, and locally supplant fluvial and glaciofluvial deposits. The second type occurs as thin (<30 cm), discontinuous veneers mantling glacial and fluvial landforms with a variety of surface expressions and slopes ranging to about 30%. These are derived locally by sheet erosion of surrounding materials.

Two fluviolacustrine material units are identified in Banff and Jasper. Differentiation is based on the distinctive geomorphic environments outlined above and on chemical characteristics. Altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) encompasses, primarily, slope wash sediment with altered chemical properties that reflect pedogenic processes. Calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) encompasses calcareous sediment on backwater portions of floodplains.

FLUVIOLACUSTRINE MATERIAL A

Concept and Distribution

Modally, Fluviolacustrine material A encompasses fine textured and stratified, chemically altered, slope wash sediment deposited by nonglacial, unconfined water flow. This material occurs as thin (usually <30 cm), mineral surface veneers but includes the noncalcareous, floodplain plus slopewash sediments of the Num-Ti-Jah 3 (NT3) Ecosite. In essence, Fluviolacustrine material A can be considered as the product of the sheet erosion process that modifies other genetic materials.

Source areas for Fluviolacustrine material A are local and include adjacent and shared landforms composed of morainal, colluvial, glaciolacustrine, and fluvial genetic materials. In many areas, eolian veneers, especially altered, medium textured eolian material (Eolian material B), have been redeposited as Fluviolacustrine material A. Deposition generally occurs downslope on gentler slopes or where established vegetation traps sediment. The resulting veneers commonly mantle morainal, glaciolacustrine, and fluvial landforms occurring in physiographic positions that receive high amounts of surface runoff. These

positions include shoulders and valley, cirque, and col floors and lower slopes. Veneers of Fluviolacustrine material A are most extensive on wet (imperfectly to very poorly drained) landscape and occur in all Ecoregions. Process status may be active or inactive with active aggradation occurring locally on wet landscape.

Surface Expression and Modifying Processes

Fluviolacustrine material A occurs most extensively as thin (usually <30 cm), discontinuous veneers mantling morainal, glaciolacustrine, and fluvial landscape. Surface expression remains that of the underlying morainal (inclined, hummocky, and ridged), glaciolacustrine (ridged, hummocky, and undulating), and fluvial (fan and apron) landforms. Slopes commonly range from 0 to 30%. The combination floodplain plus slope wash sediment characterizing the Num-Ti-Jah 3 (NT3) Ecosite is thicker than normal and forms level floodplains with gently inclined margins. Processes that modify fluviolacustrine veneers include wind throw of trees and, at high elevations, solifluction or cryoturbation. These processes affect surfaces and usually mix Fluviolacustrine material A with underlying materials. Floodplain deposits often have a few shallow channels (Eroded modifier, C.S.S.C. 1978b) with their slightly elevated natural levees.

Textural Properties

Fluviolacustrine material A is fine textured and stratified. High contents of silt and/or clay are characteristic. Sand content commonly ranges from 0 to 20%, clay content from 15 to 50%. Coarse fragments are usually absent but may range to 5% by volume. These are generally introduced by mixing processes such as solifluction.

Textural variation among selected A, B, and C horizon samples of Fluviolacustrine material A is shown in Fig. 16. It is assumed the pedogenic alteration has had minor effects on textural qualities of A and B horizons. Fluviolacustrine material A is slightly finer textured than Fluviolacustrine material B, but its textural range overlaps that of glaciolacustrine sediment. Landscape position, stratification, structure, and bulk density differentiate Fluviolacustrine material A from Glaciolacustrine material, as discussed previously.

In many cases, Fluviolacustrine material A consists of reworked and redeposited, altered, medium textured eolian material (Eolian material B). Consequently, they resemble one another, both having high silt content, low bulk density (about 0.5 to 1.5 g/cm^3 for a few measured samples), and similar soil development (pedogenic alteration). However, Fluviolacustrine material A normally has higher clay content as a result of the reworking.

Calcareousness and Reaction Properties

Chemical properties of Fluviolacustrine material A are described as altered for two reasons. First, this sediment originated as an erosional product of unconsolidated mineral surfaces that were exposed to weathering (pedogenic) processes over varying lengths of time. Secondly and more important, most Fluviolacustrine material A veneers comprise the mineral surface of soils where pedogenic weathering is the strongest. With sufficiently long periods of stability, leaching of carbonate and acidification occur during A and B horizon development. Consequently, the original qualities are unknown. Only sediment comprising the landforms of the Num-Ti-Jah 3 (NT3) Ecosite are known to have originated from dominantly noncalcareous sources. Recent and aggrading Fluviolacustrine material A of some fluvial fans and aprons is occasionally calcareous and alkaline.

Fluviolacustrine material A comprised dominantly of reworked, altered, medium textured eolian material (Eolian material B) has inherited the latter's primary mineral constituents. Soils developed in the two materials are similar, having strongly developed B horizons with high pyrophosphate-extractable iron and aluminum contents and, under certain climatic, vegetational, and moisture regimes, high humus contents.

Discussion

Altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) occurs extensively, thinly mantling other genetic material landforms, especially under wet conditions. Unusually thick deposits dominate the Num-Ti-Jah 3 (NT3) Ecosite. Fluvio- material A veneers overlying morainal deposits form the subdominant landform of the Sphinx (SX) Ecosection. It is a minor constituent of numerous other Ecosites.

FLUVIOLACUSTRINE MATERIAL B

Concept and Distribution

Modally, Fluviolacustrine material B encompasses calcareous, fine textured and stratified sediment deposited on backwater portions of floodplains by ponding of mainly glacial waters. It is the thickest and most stratified of the two fluviolacustrine material units and is confined to broad, valley floor floodplains where it overlies, interbeds with, and locally supplants fluvial and glaciofluvial sediments. A few backwater floodplains are dominated by Fluviolacustrine material B. Delta-like floodplains at the heads of lakes (e.g. upper Waterfowl Lake in Banff, Smith 1975) are included in the geomorphic environments that produce these deposits. Fluviolacustrine material B is most abundant in the Montane and Lower Subalpine.

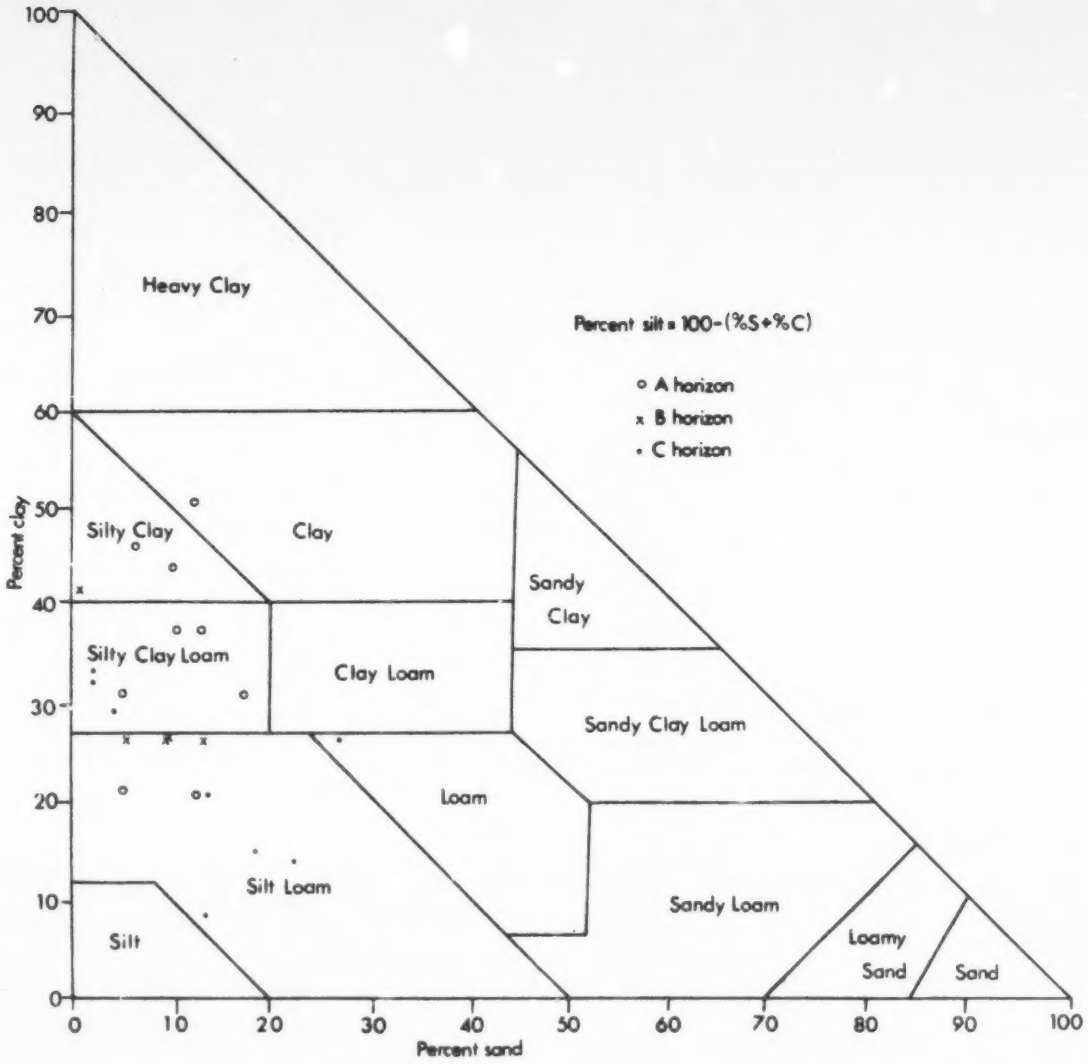


Figure 16 Textural variation among selected A, B, and C horizon samples of altered, fine textured, stratified fluviolacustrine material (Fluviolacustrine material A).

Ponding of silt-laden glacial streams on lake-head deltas and behind river channel constrictions (natural dams) promotes aggradation by siltation. Large gravelly fans produced by tributary streams often constrict major river channels, creating backwater floodplains upstream from the constrictions. Parts of the Alexandra and North Saskatchewan River floodplains are excellent examples (Smith 1972). Bedrock spurs (e.g. the bedrock ridge east of Bedson Ridge at Jasper's East Gate) and mantled, bedrock remnant landforms (e.g. Banff's Tunnel Mountain) aid river channel constriction.

Fluviolacustrine floodplains contain numerous distributary stream channels. Maximum deposition occurs during flood episodes with sediment-laden waters overflowing channel banks. Consequently, textures become progressively finer away from channels. Channel migration over time creates stratification. During low sediment cycles, moss and sedge vegetation becomes established but eventually gets buried by subsequent depositional events. Hence, Fluviolacustrine material B often contains thin layers of fibrous, silt- and clay- laden organic material. Thickness of Fluviolacustrine material B is probably quite variable. Smith (1972) reports up to 7.5 m of backwater floodplain sediment in his North Saskatchewan River study area. Underlying sediment is thought to be glaciofluvial sand and gravel on river floodplains, glaciolacustrine clays and silts on lake-head deltas.

In many areas, Fuviolacustrine material B is actively aggrading as evidenced by soils lacking surface organic layers and vegetation with poorly developed moss layers. The Hector 2 (HC2) Ecosite encompasses actively aggrading fluviolacustrine floodplains. Sedimentation on Vermilion Lakes 1 (VL1) tracts in the lower Athabasca River valley is recent and active. Some floodplains are presently inundated much of the year but by waters with low sediment loads (e.g. VL1 tracts near Banff townsite). Hence sedimentation no longer occurs and organic materials (peat) are accumulating beneath well developed moss and sedge layers.

Surface Expression and Modifying Processes

Fluviolacustrine material B is confined to level floodplains including delta-like areas of lake-heads. Slopes commonly range from 0 to 1%. Slope continuity is frequently broken by numerous, shallow, abandoned and active stream channels meandering across the landscape (Eroded modifier, C.S.S.C. 1978b). Gently sloping, slightly elevated levees border the channels.

Textural Properties

Fluviolacustrine material B is fine textured and stratified. High contents of silt and/or clay are characteristic. Sand content commonly ranges from 0 to 20%, clay content from 10 to 40%. Coarse fragments are usually absent but may range to 5% by volume.

Textural variation among selected A and C horizon samples of Fluviolacustrine material B is shown in Fig. 17. It is assumed that pedogenic alteration has had little effect on textural characteristics of A horizons. Although Fluviolacustrine material B has slighty less clay than Fluviolacustrine material A, its textural range still partially overlaps that of glaciolacustrine sediment. Landscape position and landform, stratification, intimate relationships to fluvial and glaciofluvial deposits, bulk density, structure, and organic material incorporation differentiate Fluviolacustrine material B from Glaciolacustrine material, as discussed under the Fluviolacustrine genetic material section. A silty, coarse fragment-free phase of Fluvial material B texturally overlaps silty (low clay content) Fluviolacustrine material B. They often occur together locally and distinguishing the two is usually unnecessary in such situations. Textural overlap is normal considering that the two units are often interbedded or contiguous and that each represents deposition in a part of the dynamic fluvial environment.

Calcareousness and Reaction Properties

Modally, Fluviolacustrine material B is moderately to extremely calcareous and neutral to mildly alkaline in reaction. Calcium carbonate equivalent content commonly ranges from 5 to 70%, pH values from 6.8 to 7.8. Source materials, usually fluvial, glaciofluvial, and morainal deposits upstream, are diverse and far removed from depositional localities but always include landform deposits bearing lime.

Discussion

Calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) occurs extensively on fluvial and glaciofluvial floodplains subject to episodic flooding and affected by high water tables. The Hector 2 (HC2) and Vermilion Lakes 1 (VL1) Ecosites are dominated by level floodplains comprised of Fluviolacustrine material B. Fluviolacustrine material B and the coarse fragment-free phase of Fluvial material B dominate the upper 1 to 2 m or more of the level landforms typifying the Vermilion Lakes 3, 4, and 5 (VL3, VL4, VL5) Ecosites. The floodplains of the Hector 1 (HC1), Hector 4 (HC4), and Num-Ti-Jah 2 (NT2) Ecosites often contain layers of Fluviolacustrine material B. It is a minor constituent of drier, level, fluvial landforms common to the Hillsdale (HD), Altrude (AL), and Pipestone (PP) Ecosections.

GLACIOLACUSTRINE GENETIC MATERIAL

Glaciolacustrine material encompasses fine-grained sediment deposited in proglacial lake environments. This sediment is composed of suspended material brought by meltwater streams flowing into lakes bordering glaciers (Gary et al. 1972). In Banff and Jasper glaciolacustrine material commonly overlies glacial landforms.

The textural range of glaciolacustrine material overlaps that of fluviolacustrine material. Textural stratification and lateral variability is one feature differentiating fluviolacustrine sediments from the more uniform glaciolacustrine deposits. Glaciolacustrine material is typically dense with varving and pseudo subangular blocky structure whereas fluviolacustrine material has a wide range of bulk density and shows massive structure. Fluviolacustrine material often has mineral plus organic layers; buried organic layers are absent from glaciolacustrine deposits. Fluviolacustrine deposits are not restricted to lake basins.

Glaciolacustrine material occurs in former lake basins and mantles, as blankets and veneers, gently sloping glacial landforms of valley floors and benchlands. In Banff and Jasper most of the glaciolacustrine deposits are located in the lower drainages of some tributary valleys of the Athabasca, North Saskatchewan, and Bow River valleys. Speculation

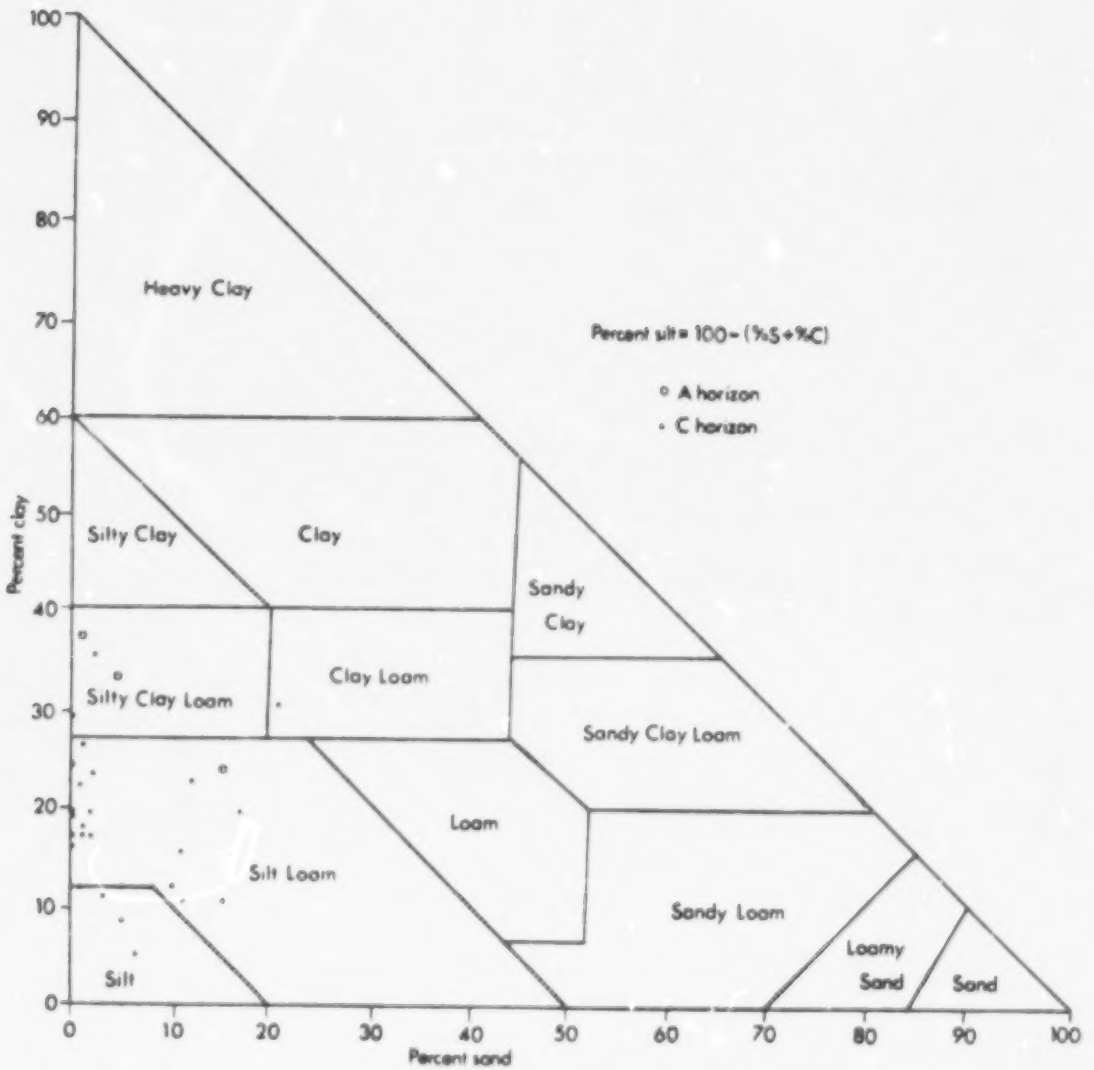


Figure 17 Textural variation among selected A and C horizon samples of calcareous, fine textured, stratified fluviolacustrine material (Fluviolacustrine material B).

is that glaciers in these major valleys dammed the tributaries. Only one glaciolacustrine unit is described in Banff and Jasper. This unit is fine textured and calcareous.

GLACIOLACUSTRINE MATERIAL

Concept and Distribution

Glaciolacustrine material is calcareous, fine-grained sediment deposited in glacial lakes and derived from calcareous unconsolidated and consolidated materials. Glaciolacustrine deposits occur mostly in the Montane and Lower Subalpine. Physiographic positions are mainly valley floors including benchlands. Known occurrences are in the lower Snake Indian and lower to middle Rocky River valleys in Jasper. In Banff, glaciolacustrine deposits occur in the lower and middle Mistaya, middle Pipestone and Cascade, and lower Spray River valleys and the Johnston Creek valley above Johnston Canyon. Noncalcareous glaciolacustrine material is of very limited extent. A noteable example occurs as a discontinuous veneer overlying noncalcareous ice contact stratified drift in the upper Miette River valley in Jasper.

Surface Expression and Modifying Processes

Glaciolacustrine material commonly occurs as blankets and veneers overlying ridged, hummocky, and undulating glacial landforms. These

are commonly complex slopes ranging from 0 to 10%.

Fluvial, fluviolacustrine and eolian processes commonly modify glaciolacustrine landform surfaces. Process status may be active or inactive. Fluvial and fluviolacustrine veneers are common on wet portions and eolian veneers are commom on dry portions. Ponding occurs occasionally on wet portions.

Textural Properties

Glaciolacustrine material commonly displays textures high in silt and clay content, hence the genetic material is labelled fine. Sand content commonly ranges from 0 to 10%, clay content from 30 to 50%. This range includes part of the silty clay loam and silty clay textural classes as defined by C.S.S.C. (1978a). Fig. 18 shows textural variation among selected C horizon samples of glaciolacustrine material. Coarse fragments are usually absent. Stratification, displaying layers with high silt content, occur locally.

Calcareousness and Reaction Properties

Glaciolacustrine material is usually calcareous, ranging from very strongly to extremely calcareous (C.S.S.C. 1978a) with pH values ranging from 7.2 to 7.4. Noncalcareous glaciolacustrine material is rare.

Discussion

Glaciolacustrine material is only recognized in the Montane and Lower Subalpine. It

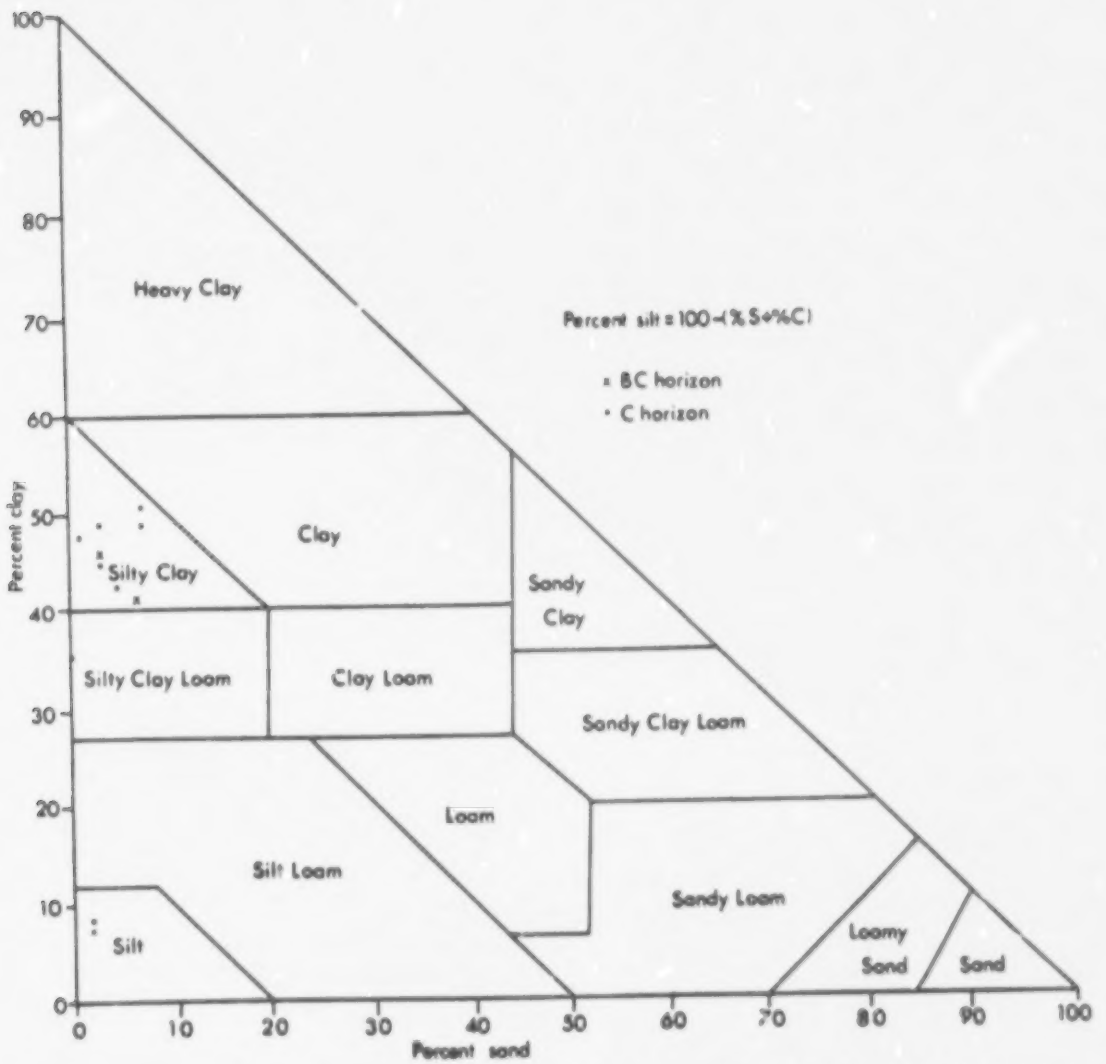


Figure 18 Textural variation among selected BC and C horizon samples of fine textured glaciolacustrine material.

dominates the glaciolacustrine landforms of the Nashan (NH) and Rocky (RK) Ecosections of the Montane, and the Merlin Castle (MC) and Spray (SP) Ecosections of the Lower Subalpine.

Thin veneers of altered, medium textured eolian material (Eolian material B) and altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) occasionally overlie Glaciolacustrine material. Glaciolacustrine material on dry portions is dominated by Luvisolic and Brunisolic soils. A range of wet soils that include Gleysols and gleyed Brunisols dominate the wet land.

EOLIAN GENETIC MATERIAL

Eolian sediment encompasses material deposited by wind. In Banff and Jasper, eolian deposits, also termed loess, are well sorted and dominated by silt (rarely <50%).

Eolian material is probably the most extensive unconsolidated mineral genetic material, but only in limited areas does it consistently exceed 30 cm in thickness. Eolian material thinly mantles many other genetic material landforms, but seldom alters their surface expression. Thicker, ridged eolian deposits (dunes) of mappable extent occur in the lower Athabasca River valley near Jasper Lake. Local eolian landforms also border extensive areas of bare mineral soil, such as near the confluence of the North Saskatchewan and Howse Rivers.

Two eolian material units are identified in Banff and Jasper, differentiated primarily on chemical (calcareousness) properties. Calcareous, medium textured eolian material (Eolian material A) is limited in distribution and encompasses thick, currently aggrading deposits, usually in the Montane Ecoregion. Altered medium textured eolian material (Eolian material B) forms thinner deposits on stable landscapes throughout Banff and Jasper. Its altered chemical properties reflect pedogenic weathering processes, showing it is older and/or more slowly aggrading than Eolian material A.

EOLIAN MATERIAL A

Concept and Distribution

Eolian material A encompasses calcareous, medium textured sediment deposited by wind. Occurrences are restricted to valley floors, benchlands, and lower valley wall slopes within the Montane Ecoregion. Deposits are mapped in the Athabasca River valley northeast of the Palisades in Jasper and in the Howse/North Saskatchewan River valley east of Glacier Lake in Banff. Distribution elsewhere is very limited, one example being the dunes occurring 1 km southeast of Banff airstrip (Rutter 1972).

Major source areas for Eolian material A include the wide, braided channels of the Athabasca River in Jasper and the Howse/North Saskatchewan Rivers in Banff. Winds channeled down these valleys pick up silt, fine and very fine sand, and some clay from the loose, unvegetated, glaciofluvial surfaces and transport them down valley (see Plate 101 in Chapter IV). Deposition occurs primarily in vegetated areas on valley floors, benchlands, and lower valley wall slopes. Process status for Eolian material A is active, based on associated soil development. Degree of activity (rate of deposition) decreases upslope from the valley floors.

Surface Expression and Modifying Processes

Eolian material A forms ridged landforms (dunes) on the Athabasca River floor from the head of Jasper Lake to Jasper's East Gate. These belong to the Devona (DV) Ecosection. Thickness of Eolian material A ranges to about 25 m in the Jasper Lake/Talbot Lake area but is shallower down valley. Slopes range from 5 to 30%.

Above the valley floor, Eolian material A forms veneers and, occasionally, blankets overlying the glacial deposits dominating the rivers' erosional scarps, benchlands, and lower valley wall slopes. Deposits are thickest (approximately 1 m) near the valley floors and become thinner upslope away from the river channels. Underlying deposits include morainal and ice contact stratified drift deposits. Inclined, hummocky, and ridged surface expressions reflect river erosion, bedrock control, or glacial deposition and are not masked by the eolian deposits. Slopes commonly range from 5 to 70%. Such polygenetic landforms typify the Talbot (TA) Ecosection. Veneers of Eolian material A mantle other landforms on valley floors along the lower Athabasca River in Jasper and the North Saskatchewan River in Banff (e.g. fluvial fans, glaciofluvial terraces).

Processes modifying Eolian material A are primarily those which erode, mix, and rework surface layers. Deflation producing blowouts is common on the dune landforms. Shallow tree root systems often occur on landforms with eolian veneers and the trees are susceptible to wind throw. This process often mixes underlying material with Eolian material A. The effects of water are intermittent and localized and include erosion and reworking of surfaces by sheet flow, stream channel overflow, and gullying on steep morainal slopes.

Textural Properties

Modally, Eolian material A is medium textured and typified by high silt content (rarely

<50%). Sand content commonly ranges from 0 to 40%; clay content from 5 to 20%. The sand fraction is typically dominated by the fine and very fine sand size separates. Coarse fragments are usually absent but may range to 5% by volume. These are generally introduced by mixing processes such as wind throw of trees.

Textural variation among selected A, B, and C horizon samples of Eolian material A is shown in Fig. 19. It is assumed that pedogenic alteration has had little effect on textural qualities of A and B horizons. A coarse textured variant, with up to 70% sand, dominated by the fine and very fine sand separates, occurs adjacent to source areas in Jasper. However, the sand content diminishes rapidly downwind from source areas.

Other physical features of Eolian material A include low bulk density (0.7-1.2 g/cm³ measured on 4 horizons), very friable consistence, massive structure, and lack of mineral stratification. Buried organo-mineral (Ahb) horizons may occur and mark the positions of nearly stable, slowly accreting surfaces that were subsequently buried by renewed, more rapid eolian deposition.

Calcareousness and Reaction Properties

Eolian material A is usually strongly to extremely calcareous and mildly to moderately alkaline. Calcium carbonate equivalent contents commonly range from 15 to 70%; pH values from 7.3 to 8.3.

Weakly developed pedogenic horizons occur at

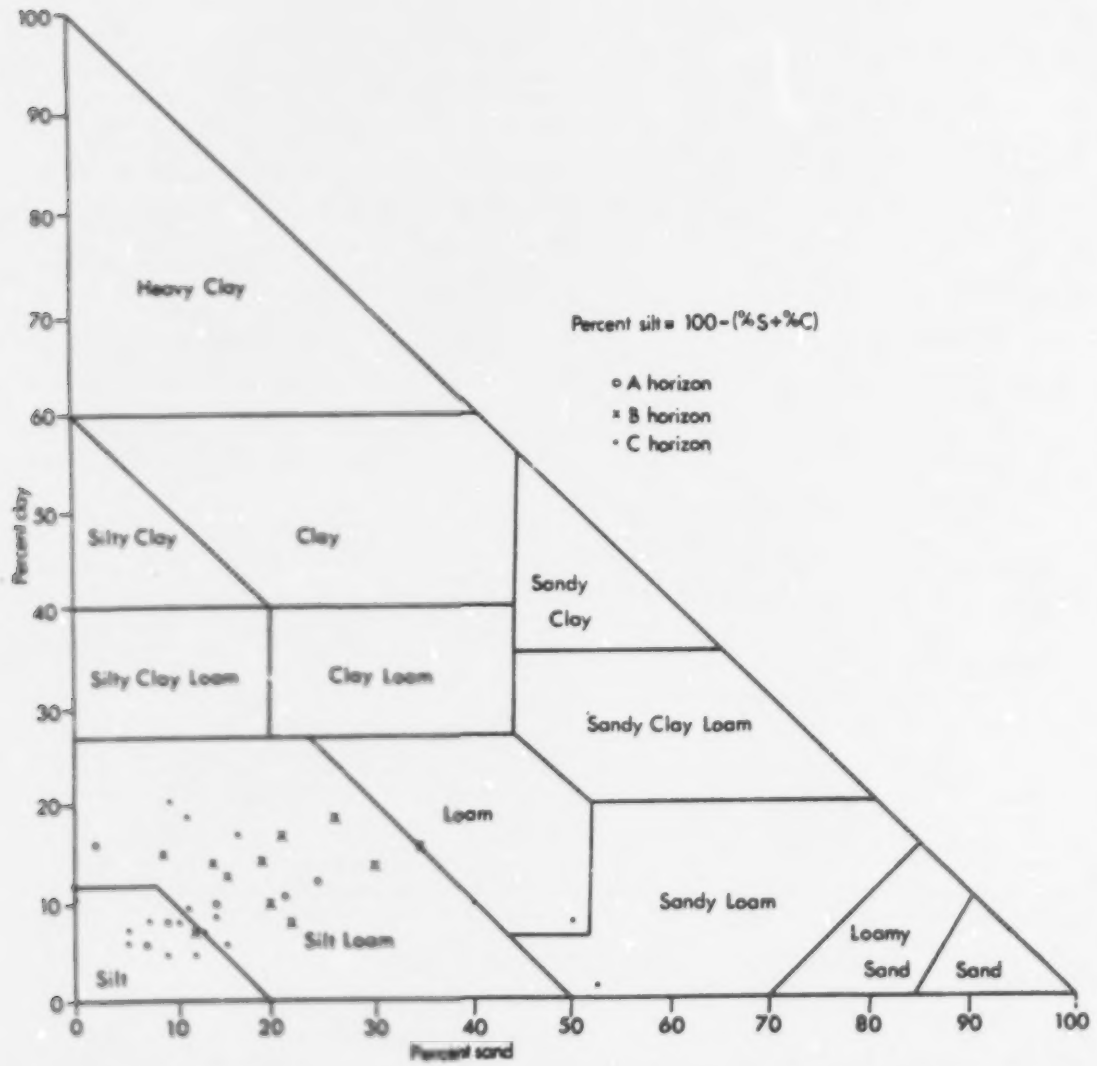


Figure 19 Textural variation among selected A, B, and C horizon samples of calcareous, medium textured eolian material (Eolian material A).

higher elevations where deposition rates are low. These plus buried A and B horzons may have lower carbonate content (rarely <1%) and pH (rarely <7.0), although they commonly contain secondary carbonate illuviated from layers above. Hence, Eolian material A surfaces are continually receiving varying amounts of calcareous material.

Discussion

Calcareous, medium textured eolian material (Eolian material A) is the thickest but least extensive of the two eolian material units. It is restricted to the Montane Ecoregion and occurs in the lower Athabasca River valley in Jasper, and the Howse/North Saskatchewan River valley in Banff. The ridged landforms of the Devona (DV) Ecosection are comprised of Eolian material A. Landforms of the Talbot (TA) Ecosection are characterized by Eolian material A veneers overlying glacial deposits.

A minor constituent of Eolian material A is volcanic ash. Westgate and Dreimanis (1967) described two distinct volcanic ash layers plus reworked ash layers in a section through a loess deposit near Saskatchewan Crossing in Banff. Grain size distribution of Bridge River ash samples presented by Westgate and Dreimanis (1967) is similar to that of Eolian material A.

EOLIAN MATERIAL B

Concept and Distribution

Eolian material B encompasses chemically altered, medium textured sediment deposited by wind. It is the most extensive of the unconsolidated mineral materials, but rarely exceeds 30 cm in thickness. It mantles a variety of landforms on all physiographic positions in all Ecoregions but is most extensive on older, relatively stable surfaces such as morainal landscape. Depth and extent of Eolian material B veneers are greatest in the southwest and decrease to the north and east. Hence, the deepest (15 to 30 cm) and most extensive deposits occur on stable surfaces in western Banff (including southern Banff south of the townsite) and southwestern Jasper.

Smith (1979) presents evidence that veneers of eolian origin (Eolian material B) occurring as the upper sola of pedons in the Sunwapta Pass area of Jasper are composed of local detritis with admixed volcanic ash. Other soil studies conducted in the North Saskatchewan River valley outside Banff National Park (Pettapiece and Pawluk 1972), in the Sunshine area (Pawluk and Brewer 1975) and at Bow Pass (King and Brewster 1976) provide substantiating evidence. Surface (upper sola) occurrences of eolian sediment containing volcanic ash are documented for Banff and southern Jasper and areas immediately east of the parks (Westgate and Dreimanis 1967, Pettapiece 1971, Beke and Pawluk 1973, Knapik et al. 1973, Pawluk and Brewer 1975, King and Brewster 1976, and Smith 1979). Ash layers buried by colluvial, fluvial, fluviolacustrine, eolian, and organic deposits have also been recorded within and adjacent to Banff and Jasper (Westgate and Dreimanis 1967, McPherson and Hirst 1972, Smith 1972, Roed and Wasylyk 1973, Smith 1975). Several of these researchers have identified three major postglacial ashfalls, traceable to major volcanic events occurring in the northwestern United States and southwestern British Columbia. Ejecta plumes tracked northeastwards from the sites of volcanism (Powers and Wilcox 1964, Nasmith et al. 1967, Westgate and Dreimanis 1967, Harward and Youngberg 1969, Westgate et al. 1969). The three major ashfalls are Mazama ash dated to 6600 years B.P., St. Helens Y ash dated to approximately 3200 years B.P., and Bridge River ash dated to about 2400 years B.P. The most extensive ash is Mazama.

Surface veneers containing ash do not have discrete strata comprised of ash and/or local detritis. Hence, Eolian material B is essentially mineralogically uniform (Smith 1979), its constituents having been mixed by various agents including redeposition by wind, windthrow of trees, soil creep, and solifluction. Fresh moraine, outwash plains, and exposed, unvegetated colluvium and rock are the local sources winnowed to produce detritus for eolian transport and deposition. It is thought that over most of Banff and Jasper, accumulation of Eolian material B has essentially ceased, with only microscopic amounts presently accreting. Areas adjacent to glaciers, fresh moraines and unvegetated glacial meltwater channels may receive more wind-blown material.

Surface Form and Modifying Processes

Eolian material B occurs most extensively as thin (usually <30 cm) veneers mantling relatively stable surfaces of older genetic materials and bedrock. The most common underlying material is glacial till. The veneers are discontinuous, having been subjected to redeposition by wind and post-depositional, erosional and mixing processes. These processes include sheet erosion (washing), gully erosion, colluviation, avalanching, and, at high elevations, solifluction and cryoturbation. On wet, seepage-affected landscape, washed and redeposited Eolian material B is a common constituent of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A).

Textural Properties

Modally, Eolian material B is medium textured and typified by high silt content (rarely <50%). Sand content commonly ranges from 10 to 50%; clay content from 0 to 25%.

The sand fraction is dominated by the fine and very fine sand size separates. Coarse fragments are usually absent but may range to 5% by volume. These are generally introduced from underlying materials by pedoturbation processes such as windthrow of trees, soil creep, and solifluction.

Textural variation among selected A, B, and C horizon samples of Eolian material B is shown in Fig. 20. It is not known to what extent pedogenic weathering and eluviation have altered the textural qualities of A and B horizons. Altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) consisting of reworked and redeposited Eolian material B usually displays higher clay content than its precursor. Other physical features of Eolian material B include low bulk density (0.6-1.4 g/cm^3 measured on a few samples), very friable consistence, massive structure, and a lack of mineral stratification. Bulk density, consistence, and structure are similar for Fluviolacustrine material A and calcareous, medium textured eolian material (Eolian material A).

Calcareousness and Reaction Properties

Chemical properties of Eolian material B are termed altered. This is because it occurs as surficial veneers, thereby comprising the mineral surface of soils where pedogenic weathering is the strongest. With sufficiently long periods of stability, leaching of carbonate and acidification occur during A and B horizon

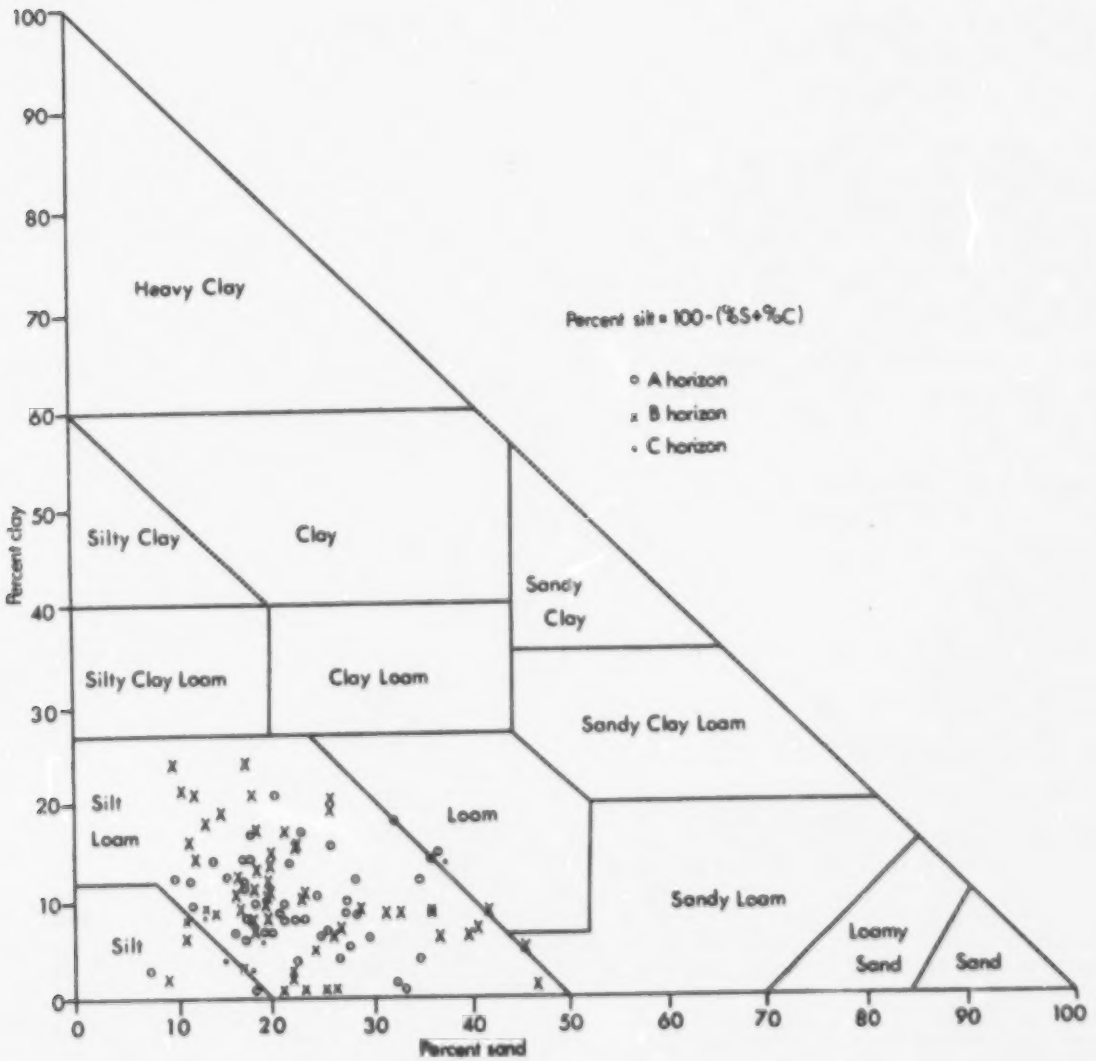


Figure 20 Textural variation among selected A, B, and C horizon samples of altered, medium textured eolian material (Eolian material B).

development. Consequently, the original calcareousness and reaction qualities are unknown.

Soils occurring in Eolian material B veneers overlying other genetic materials are frequently characterized by somewhat amorphous, very friable B horizons with moderate to high chroma developed above the parent material disconformity. This distinctive B horizon often contains high amounts of pyrophosphate-extractable (organically complexed) iron and aluminum and, at high elevations, high humus contents. Free iron and aluminum oxide are derived by weathering of primary minerals from both ash and non-ash (local) sources (Smith 1979).

Discussion

Altered, medium textured eolian material (Eolian material B) is the thinnest but most extensive of the two eolian material units. No Ecosection or Ecosite separations in the Banff-Jasper Ecological Land Classifictaion system are based on the presence of this material. It is, however, a common but inconspicuous component of many Ecosites. Ecosites characterized, in part, by Podzolic soils or Brunisolic Gray Luvisols have, as an accessory feature, eolian veneers referring specifically to Eolian material B. Gleyed Podzolic soils occur on wet, seepage-affected landscape, their upper sola horizons being developed mainly in Fluviolacustrine material A consisting primarily of reworked Eolian material B. Volcanic ash occurring as thin buried layers within organic and stratified fluvial deposits is included within the concept of Eolian material B.

ORGANIC, CONSOLIDATED, AND ICE COMPONENTS

The organic, consolidated, and ice components are not subdivided within the Banff-Jasper Ecological Land Classification taxonomy. The organic component is of limited areal extent and thinly mantles unconsolidated mineral deposits. The consolidated (bedrock) and ice components lack soil and vegetation.

ORGANIC COMPONENT

The organic component consists of peat deposits containing >30% organic matter by weight (>17% organic carbon) that may be as thin as 10 cm if they overlie bedrock but are otherwise greater than 40 cm (C.S.S.C. 1978b). In Banff and Jasper the organic component is of limited areal extent and thinly mantles unconsolidated mineral deposits.

Organic landforms consist predominantly of fen peat, represented by the component symbol N, derived primarily from sedges and brown mosses (e.g. *Tomenthypnum nitens* and *Aulacomnium palustre*). In several areas fen vegetation has been succeeded by open and closed forest.

Ground water discharge and high water tables promote the development of organic material. Fens develop where the mineral component is stable, thus enabling build up of organic material. These locales are very poorly to poorly drained and are frequently ponded. Favorable moisture, nutrients and vegetation have resulted in the accumulation of varying thicknesses of fen peat but they rarely exceed 1.2 m in thickness.

Fen peat is medium acid to neutral (pH 5.5-7.5) in reaction. Moderate decomposition is characteristic but fibric and humic layers also occur. Fen peat is relatively low in fiber with a 10 to 40% rubbed fibre content (C.S.S.C. 1978b). Organic materials occasionally contain partially decayed wood fragments. They may also contain thin layers of altered, medium textured eolian material (Eolian material B).

Topographically, organic landforms display gentle linear slopes commonly ranging from 0 to 15%. Two classes exist in the parks, horizontal and sloping. These occupy level floodplains and toes of fluvial aprons and fans. They also occur on sloping discharge and depressional areas on glacial and proglacial landforms.

Organic landforms occur in all Ecoregions of Banff and Jasper but are most extensive in the Montane and Subalpine. In the Montane Ecoregion organic landforms comprise part of the Patricia 5 (PT5) and Vermilion Lakes 1 (VL1) Ecosites. They comprise minor portions of the Nashan 1 (NH1) and Vermilion Lakes 3 (VL3) Ecosites. In the Lower Subalpine, organic landforms comprise part of Baker Creek (BK) and Consolation Valley (CV) Ecosections and part of the Cavell 1 (CA1), Topaz (TZ2) and Hector 1 and 4 (HC1, HC4) Ecosites. They comprise minor portions of the Merlin Castle 1 (MC1) Ecosite. In the Upper Subalpine, organic landforms comprise parts of the Azure 1 (AZ1) and Num-Ti-Jah 3 (NT3) Ecosites. In the Alpine Ecoregion, organic landforms are of minor importance. Organic layers occur locally in several other Ecosites throughout all Ecoregions of the parks.

CONSOLIDATED COMPONENT (BEDROCK)

Bedrock is the only consolidated component class recognized. It consists of tightly packed lithified materials. Excluding materials indurated by pedogenic processes, bedrock is material harder than 3 on Mohs' hardness scale. Effectively, this is material too hard to break with the hands or to dig with a spade when moist (C.S.S.C. 1978b).

Bedrock underlies all other materials in the

parks, at greatest depths in the major valley floors. It crops out throughout all Ecoregions, with locations dependent on lithology, structure, and erosional history. Most outcrop occurs at high elevations. Surface expressions are generally steep, but at lower elevations there are ridged and occasionally hummocky instances. Massive, resistant rock is more prominent in the landscape than recessive bedrock.

Bedrock is the source of all unconsolidated mineral material in the parks save the volcanic component of Eolian material B. For purposes of this Ecological Land Classification, three major lithologic groups are important (Table 5). Though these groups strongly influence their immediate landscape, especially in areas where unsorted sediments are derived directly from them, bedrock as such is not subdivided.

The Miscellaneous Landscape Rockland (R) is mapped with bedrock as the principal landform, as is the Heather 2 (HE2) Ecosite.

ICE COMPONENT

The ice component forms by the compaction and recrystallization of year-round snow. In Banff and Jasper this includes glaciers, icefields, glacierettes, and firn. The ice component occurs mainly in the Upper Subalpine and Alpine. Occurrences are rare in the Lower Subalpine, and restricted to ablating valley glaciers fed from higher elevations. Distribution of ice is primarily confined to higher elevations of the Main Ranges near the Continental Divide (Falconer et al. 1966). Occurrences and extent are limited in the Front Ranges. The ice component lacks soil and vegetation except for snow mold. In some cases though, ice is often mantled by colluvial and landslide debris from adjacent steep slopes. The ice component within Banff and Jasper is identified as the Miscellaneous Landscape Glacier (GL).

CHAPTER II

SOILS

B.D. Walker, W.D. Holland,
and G.M. Coen

INTRODUCTION

Early systematic soil description and classification in Alberta started on agricultural land in the 1920's. Soils work on the periphery of Banff and Jasper includes soil description and classification in the Subalpine forest at the Kananaskis Forest Experiment Station (Crossley 1951), Laycock's (1957) physiographic classification of soils for land use planning of the Eastern Slopes of the Canadian Rockies, and a soil survey of Marmot Creek basin (Lindsay and Peters 1964). Land classification using biophysical principles was conducted by Pettapiece (1971) along the North Saskatchewan River valley. Other work east of the parks included land classification at Kananaskis by Duffy and England (1967) and studies by Dumanski (1970), Dumanski and Pawluk (1971), and Dumanski et al. (1972) investigating the genesis of soils developed on calcareous eolian material in Jasper and near Hinton, along with soil survey and land evaluation in the Hinton-Edson area. Soil survey and interpretations in the mountains and foothills of the Wapiti map area north of Jasper Park were conducted by Twardy and Corns (1980).

Soil survey to the west of Banff was done by Kelley and Sprout (1956), Kelley and Holland (1961) and in Yoho by Coen et al. (1977).

Description and classification of soils in Banff and Jasper were begun fairly recently. Initial efforts were site specific and linear transect studies, mostly as student research, but gradually became oriented to answering particular park problems. Among these workers were Baptie (1967) on the ecology of Alpine soils, King (1971) investigating soil in Castleguard Meadows, and Knapik (1972) and Knapik et al. (1973) looking at soils and soil and plant relationships in the Sunsine ski area. Ogilvie and Baptie (1967) reported on permafrost, as did Scotter (1975) and Achuff and Coen (1980). Root and Knapik (1972), followed by Epp (1977), examined soils in relation to trail conditions.

A number of site specific studies provided descriptions of soils and vegetation, for example the visitor impact study in the Sunshine-Egypt Lake area of Banff where Lesko and Robson (1975) examined damage to vegetation and soils as a result of campground use. Site specific descriptions in Banff and Jasper were prepared by Knapik and Coen (1978) for a tour by members of the International Society of Soil Science.

Soil survey and land inventory studies were begun in Banff by Noakes and Harris (1971), Harris et al. (1973), Harris (1974), and the Lombard North Group Ltd. (1974). The early land classification projects were superseded by the work of Walker et al. (1978), using the biophysical land classification methods and concepts of Lacate (1969) and Holland (1976). Broad scale holostic land classification for southwestern Alberta was reported by Kojima (1980) using the biogeoclimatic methodology of Krajina (1959), and information supplied by the Banff-Jasper Ecological Land Classification team.

A wide range of techniques and presentations of natural resource inventories is evident from the foregoing, the nature of which is dependent upon the purpose and recipient of the information. A common theme is the development of techniques and concern for improved description, inventory, classification, and interpretation of the soil resource in relation to other resources. Ultimately, it is hoped that such study will develop an appreciation for improved park land use and conservation of soil and other resources.

SOIL FORMATION, TAXONOMY, AND DISTRIBUTION

FACTORS OF SOIL FORMATION

Five environmental factors are generally considered to affect soil formation, and are discussed in detail by Jenny (1941), Buckman and Brady (1969), and Buol et al. (1973). These factors are climate, particularly temperature and precipitation; living organisms, especially the type of vegetation cover and organic matter accumulation; tne kind of parent material, that is, its texture, mineralogical and chemical composition; the relief of the area, including topography, elevation and drainage; and finally the time (or length of stability) that parent materials are subjected to soil formation.

The interaction of these soil-forming factors has resulted in many different kinds of soil throughout Banff and Jasper. The relative importance of each factor differs from place to place. Site specific pedogenic studies in Banff, Jasper, and adjoining areas are of interest from the standpoint of gaining some insight into ecological relationships. Several pedogenic studies deal with soil pedons developed from two different geomorphic materials, the upper one being of eolian origin and containing varying amounts of volcanic ash and the lower one being mainly of morainal origin. These studies were conducted on soils from the North Saskatchewan River valley east of the Banff National Park boundary (Pettapiece and Pawluk 1972), Marmot Creek basin southeast of Banff (Beke and Pawluk 1971), the Sunshine area in Banff and Luscar Mtn. east of Jasper (Pawluk and Brewer 1975), Bow Pass in Banff (King and Brewster 1976), and Sunwapta Pass in Jasper (Smith 1979). Pettapiece and Pawluk (1972) and Smith (1979) investigated "besequa" profiles with podzolic-like morphologies overlying luvisolic-like morphologies. Pawluk and Brewer (1975) point out the importance of soil fauna in the development of Alpine soils. Dumanski and Pawluk (1971) investigated soils developed in calcareous, eolian deposits located between Jasper's East Gate and Hinton. Baptie (1967) studied the ecology of soils in the Snow Creek valley, Banff. Achuff and Coen (1980) noted climate—soil—vegetation relationships for a Cryosolic soil in the Mt. White area in eastern Banff.

SOIL ORDERS IN BANFF AND JASPER

The soil taxonomy used in Banff and Jasper is the Canadian System of Soil Classification (C.S.S.C. 1978b). Representatives of eight soil Orders occur in the parks, including the Brunisolic, Luvisolic, Podzolic, Chernozemic, Cryosolic, Regosolic, Gleysolic, and Organic Orders.

The first three reflect, by their degree of horizon differentiation and certain morphological characteristics, various mesoclimates within the broader Ecoregions and certain parent material characteristics. The Chernozemic and Cryosolic Orders appear to be controlled by meso- or microclimatic influences and rather specific but unidentified parent material characteristics which affect small geographic areas. The Regosolic Order reflects active or recently active geomorphic processes. The Gleysolic and Organic Orders reflect the interaction of topography and hydrologic flow regimes (high water tables, near-surface seepage, groundwater discharge, and surface water collection).

Soils of the Brunisolic Order are the most abundant of those Orders occurring in Banff and Jasper. Changes in the balance of soil forming factors tends to result in changes in soil characteristics along a taxonomic continua toward other Orders. Many of the Ecosites are characterized by soils occurring along this continua near the Brunisolic Order boundary with other Orders.

THE BRUNISOLIC ORDER

In Banff and Jasper, the Brunisolic Order is broad in concept, the most extensive relative to other Orders, and encompasses a wide range of characteristics. Brunisols are frequently associated with soils of several other Orders under varying climatic, vegetational, and geomorphic conditions. These characteristics and relationships are explored briefly in the discussion that follows.

Great Groups

The Brunisolic Order is subdivided into 4 Great Groups based on solum reaction and A horizon characteristics. All four Great Groups occur in Banff and Jasper.

A major distinction is based on solum reaction. Eutric and Melanic Brunisols have medium acid to mildly alkaline (pH >5.5), middle to lower sola, including specifically the B horizon and underlying horizons to a thickness of 25 cm. They are developed on calcareous geomorphic materials including, in some areas, those with low lime content.

Dystric and Sombric Brunisols are common in Banff and Jasper, but less extensive than the Eutric and Melanic Brunisols. Dystric and Sombric Brunisols have extremely to strongly acid (pH of 5.5 or less), middle to lower sola, including specifically the B horizon and underlying horizons to a thickness of 25 cm. They are developed on noncalcareous geomorphic materials including, in some areas, those with low lime content.

Melanic and Sombric Brunisols are distinguished from Eutric and Dystric Brunisols, respectively, by thick (10 cm or more)

organo-mineral (Ah) horizons. Such horizons develop under non-forested vegetation where organic matter incorporation and humification is important. Soil fauna are important in these processes (Pawluk and Brewer 1975). These two Great Groups occur in complex environments where Ah horizon thickness is quite variable and other processes are important locally. Hence, Melanic and Sombric Brunisols are intimately associated with Eutric and Dystric Brunisols and soils of several other Orders. A horizon features of Brunisolic soils are explored in greater detail in a following section.

B Horizon And Lower Solum Characteristics of Brunisolic Soils

As previously mentioned, Brunisolic soils display a wide range of characteristics. This is particularly pertinent to Brunisolic B horizon and lower solum development. B horzon differentiation ranges from weak (Brunisolic—Regosolic soil complexes) through intermediate to strong (Brunisolic—Podzolic soil complexes) including those with luvisolic tendencies (Brunisolic—Luvisolic soil complexes), depending on mesoclimatic and geomorphic conditions. Lower sola may also display evidence of weak gleying, related to drainage characteristics.

Brunisolic soils with weakly expressed and poorly differentiated B horizons (5 cm or more thick) are often associated with Regosolic soils on some geomorphically active terrain. Orthic Dystric Brunisols, Orthic Eutric Brunisols, and Orthic Melanic Brunisols are the Subgroups most often found in such situations. Steep colluvial landforms frequently have a Brunisol—Regosol soil complex but some landslide deposits, steeply sloping morainal tracts, and recently stabilized fluvial landforms display a similar soil pattern. The geomorphic processes generally involve differential (locally varying intensity) erosion or deposition and include avalanching, soil creep, sheet and gully erosion, windthrow of trees, fluvial deposition, eolian deflation and deposition, solifluction, and cryoturbation. Recently stabilized slopes also frequently exhibit a Brunisol—Regosol soil pattern.

Eutric Brunisols occurring on warm, dry glacial and glaciolacustrine landforms in the Montane and Lower Subalpine frequently have B horizons with luvisol-like morphologies. These Orthic and Eluviated Eutric Brunisols are intimately associated with Luvisolic soils and have brownish (often 7.5YR 4/4 m; Munsell color notation) Bm or Btj horizons developed at the mineral surface or below an Ae—Bm horizon sequence occurring in thin veneers of altered, medium textured eolian material (Eolian material B), where present. These B horizons display high clay contents compared to adjacent horizons, but structure (subangular blocky) and clay film development are weak. They also frequently show evidence of incomplete carbonate removal. The Brunisol—Luvisol complex of soils are generally well to moderately well drained, occasionally rapidly and imperfectly drained, and occur under lodgepole pine forests. Mesic to subxeric Engelmann spruce—subalpine fir forests, namely the Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower /feathermoss (C31) and Engelmann spruce/hairy wild rye (C33) v.t.s ocurring on southerly aspects in the Front Ranges, are also associated with Brunisolic soils displaying luvisolic tendencies. In some areas, this soil complex extends as high as 2000 m on southerly aspects and 1800 m on northerly aspects but the luvisolic tendencies diminish and the incidence of Luvisolic soils decreases with increasing elevation.

Brunisolic soils with moderate or intermediate horizon development occur under intermediate mesoclimatic conditions or on stable genetic materials that do not promote luvisolic or podzolic tendencies as a result of pedogenic weathering. These materials include glacial landforms on northerly aspects and at high elevations in eastern Banff and eastern and northern Jasper, fluvial and glaciofluvial landforms with old, stable surfaces, some Subalpine landslide and residual landforms, and, occasionally, noncalcareous colluvial landforms. The moderately developed Brunisols generally have brownish Bm horizons with low to moderate amounts of humus and pyrophosphate extractable iron and aluminum. Underlying horizons (BC or lower B horizons) occasionally exhibit rudimentary luvisolic tendencies, especially where developed on calcareous glacial materials, but such features are attributed primarily to differential removal (weathering) of carbonate material from the soil mass (Smith 1979). Eluviated Dystric Brunisols with duric tendencies (weak cementing) in lower B and BC horizons occur frequently on noncalcareous, coarse textured materials, namely noncalcareous, coarse textured till (Till A), noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A), and noncalcareous, coarse textured glaciofluvial material (Glaciofluvial material A). These soils also dislay unusually deep Ae horizons and sola where Eolian material B is absent. The moderately developed Brunisols occur under rapidly to imperfectly drained moisture conditions and a variety of vegetation types, excluding most lodgepole pine forests occurring on calcareous glacial materials.

Under cool, moist Subalpine and Alpine climatic conditions where veneers of Eolian material B are extensive, Brunisolic soils are generally strongly developed, displaying podzolic tendencies, and associated with Podzolic soils. Distribution of these soils corresponds to the distribution of Eolian material B under well to moderately well drained conditions

and altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) derived from Eolian material B under imperfectly to poorly drained conditions. Hence, the Brunisol—Podzol complex of soils is most extensive in western Banff and southwestern Jasper, particularly on glacial landforms. These soils occur under Engelmann spruce—subalpine fir forests at intermediate elevations, under subalpine larch and heath tundra vegetation at higher elevations. The strongly developed Brunisols are characterized by reddish, dark and strong brown Bm, Bfj, Bf, or Bhf horizons developed immediately above the parent material disconformity. These horizons have moderate to high pyrophosphate extractable iron and aluminum contents, weathered from the eolian genetic material. They also display, generally, increasing illuvial—humus content with elevation or with increasing wetness (imperfectly to poorly drained). Under forest vegetation, eluvial (Ae) horizons often overly the B horizons. In the Alpine and Upper Subalpine—Alpine ecotone, overlying horizons are humus rich (Ahe or Ah). Underlying genetic materials may be either calcareous, giving Eutric and Melanic Brunisols, or noncalcareous, resulting in Dystric and Sombric Brunisols.

Brunisolic soils exhibiting the full range of B horizon characteristics occur under imperfectly to poorly drained conditions on sites affected by seepage. These are usually intimately associated with Gleysolic and gleyed Podzolic soils. The most common Subgroups are Gleyed Dystric Brunisols and Gleyed Eutric Brunisols. They generally display weak mottling in a matrix background of moderate chroma. Consequently, evidence of strong gleying and anaerobic conditions, i.e. dull colors and/or strong mottling, is absent from the upper 50 cm of mineral soil, even though neighboring pedons may be strongly gleyed. A variety of climatic, geomorphic, and hydrologic factors contribute to the varying intensity of gleization across seepage affected landscape. Thin organic layers (peaty horizons) may or may not mantle the mineral soil. A horizons are absent or thin and where present, are generally Ah or Ahe. Eluvial (Ae) horizons occur infrequently. Gleyed Brunisolic soils are common on glaciolacustrine landforms in the Lower Subalpine but are most extensive on seepage affected morainal landforms in the Upper Subalpine.

A Horizon Characteristics of Brunisolic Soils

Brunisolic soils occasionally lack A horizons. Frequently this is because current or recent disturbances have destroyed them or inhibited their development. On more stable slopes, eluvial (Ae) horizons are common under forest vegetation. Ae horizons >2 cm thick, are diagnostic for Eluviated Subgroups within the Brunisolic Order. Of particular interest are the organo-mineral (Ah) horizons associated with Brunisolic and other soils occurring in the Alpine and Alpine—Upper Subalpine ecotone and under grassland and dry shrubland vegetation. In both environments, the Ah horizon thickness is variable and largely controlled by the kind and degree of surface disturbance. Some disturbances such as solifluction and soil creep disrupt A horizon development on some sites and physically thicken them on adjacent sites. The variable Ah horizon thickness results in the intimate association of Eutric with Melanic Brunisols, Dystric with Sombric Brunisols. Soils of other Orders, but with similar surfaces, are associated with these Brunisolic soils. However, the two environments display some basic differences.

Upper sola, including A horizons, of Brunisolic soils occurring under tundra vegetation tend to be acidic with low base saturation, regardless of the chemical characteristics of lower sola and C horizons. Further, the eluviation process is usually masked in the Alpine and Upper Subalpine—Alpine ecotone. However, under heath tundra vegetation, graying A horizons with characteristics of Ah and Ae horizons (herein termed Ahe horizons) often replace or coexist with Ah horizons. The presence of these Ahe horizons makes the distinction between Orthic and Eluviated Subgroups indefinite and each pedon must be evaluated as to degree of eluviation. Eluviated (Ae) horizons occur beneath thin Ah horizons in some pedons, particularly those developed on coarse textured materials under heath tundra vegetation. It is evident from this discussion that soil variability in the Alpine and Alpine—Upper Subalpine ecotone is great. Several Brunisolic Subgroups are intimately associated, as are soils from the Podzolic, Regosolic, and Gleysolic Orders.

Soils associated with Subalpine grasslands and dry shrublands are less variable than those in the Alpine and the Alpine—Upper Subalpine ecotone. Upper sola, incuding Ah horizons, of Brunisolic soils occurring in this warm, dry environment tend to have a neutral reaction with a high base saturation. They display a narrow range of pH from A to C horizons. Consequently, Ahe and Ae horizons giving Eluviated Subgroups are absent and, also, Dystric and Sombric Brunisols and Podzols do not occur. Recent or current geomorphic activity, mainly soil creep, is common on these steep, southerly-facing slopes (usually >30%) and Regosolic soils are common associates. There is evidence that some of the soils occurring under grassland vegetation can also be classed as Dark Brown in the Chernozemic Order. Some pedons have unusually thick Ah horizons resulting from the accretion of humified Ah material. Subalpine grasslands and dry shrublands are most common in but not confined to the Front Ranges. Shaly material, particularly that derived from Mesozoic strata, is a common con-

stituent of the morainal and colluvial materials supporting grassland and dry shrubland vegetation.

THE LUVISOLIC ORDER

Gray Luvisols occur in association with Eutric Brunisols showing luvisolic tendencies in warm, dry portions of Lower Subalpine and throughout much of the Montane. They commonly occur on calcareous, morainal, ice contact stratified, and glaciolacustrine landforms with rapidly to moderately well drained moisture regimes. Luvisolic development is best expressed on calcareous glaciolacustrine sediment.

Gray Luvisols are identified by eluvial Ae and illuvial Bt horizons, signifying presence of downwardly translocated clay. The subangular blocky structure is weak and clay films are thin and discontinuous, resulting in Bt horizons in Banff and Jasper being more weakly expressed than in much of the forested areas in Alberta. Additionally, these brownish (often 7.5YR 4/4 m, Munsell color notation) Bt horizons frequently display low carbonate content along their lower boundaries, indicating incomplete carbonate removal.

Very thin veneers of altered medium textured eolian material (Eolian material B) are common to areas with Luvisolic soils. The eolian material appears to be more easily weathered than the underlying glacial or glaciolacustrine material which it mantles. The result is an Ae—Bm horizon sequence like that of Brunisolic soils overlying the Bt horizon. Soils with such "bisequa" morphologies are classed as Brunisolic Gray Luvisol. Orthic Gray Luvisols occur where the veneer is absent, but their distribution is limited.

Gleyed Brunisolic Gray Luvisols occur occasionally and are most common on seepage affected (imperfectly drained) low lime till in the Lower Subalpine. The moraines exhibit evidence of slope failure but the seepage is periodic and affects only subsurface layers. Weak mottling in middle to lower sola and C horizons distinguishes the gleyed pedons from their better drained counterparts.

Lodgepole pine forests are usually associated with Luvisolic soils and their Eutric Brunisol associates. In a few areas, this soil—vegetation combination extends upwards as high as 2000 m on steep southerly aspects and 1800 m on northerly aspects. However, the luvisolic tendencies diminish and the incidence of Luvisolic soils decreases with increasing elevation. On some southerly aspects, spruce-fir forests, mainly the Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) and Engelmann spruce/hairy wild rye (C33) v.t.s, are associated with the Brunisol—Luvisol complex of soils.

THE PODZOLIC ORDER

Podzolic soils represent the most strongly developed soils in Banff and Jasper. They are associated with Brunisolic soils displaying podzolic tendencies and are generally confined to moist, cool environments in the Subalpine and Alpine Ecoregions. Distribution is related to the distribution of altered, medium textured eolian material (Eolian material B) and its reworked derivative that forms a significant constituent of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) in some areas. Eolian material B and Fluviolacustrine material A veneers are thickest (generally up to 30 cm) and most extensive in western Banff and southwestern Jasper. The Brunisol—Podzol complex of soils are most extensive in this area.

Reddish to dark brown podzolic B horizons (C.S.S.C. 1978b) are diagnostic of Podzolic soils. These develop immediately above the parent material disconformity and contain high amounts (>0.6%) of pyrophosphate-extractable iron and aluminum weathered from the iron and aluminum containing minerals within the surficial veneers. There appears to be little translocation of iron and aluminum oxides across the parent material disconformity to underlying horizons (Beke and Pawluk 1971, King and Brewster 1976, Smith 1979).

Orthic Humo-Ferric Podzols are most common at moderate elevations under well to moderately well drained conditions with Engelmann spruce—subalpine fir and subalpine larch forests. These have podzolic Bf horizons. There is, however, a tendency towards increasing illuvial—humus content with elevation in the podzolic B horizons. Consequently, occurences of Orthic Ferro-Humic Podzols with podzolic Bhf horizons increase with elevation under well to moderately well drained conditions. These soils are more common than the Orthic Humo-Ferric Podzols under heath tundra vegetation in the Alpine and Alpine—Upper Subalpine ecotone. Under these conditions, the Orthic Ferro-Humic Podzols often have thin Ah horizons but occurrences of Sombric Ferro-Humic Podzols are infrequent.

Podzolic soils also occur under imperfectly to poorly drained moisture regimes in the Subalpine and Alpine Ecoregions. They are associated with Gleysolic, gleyed Brunisolic, and Organic soils on seepage affected terrain. Lower sola horizons display varying degrees of gleying. A and B horizons occur in thin veneers of Fluviolacustrine material A derived as a result of slope wash reworking and redepositing Eolian material B. Under these conditions, podzolic B horizons contain high amounts of humus as well as free iron and aluminum. They are classed as podzolic Bf, Bhf, and Bh, depending upon ratios of organ-

ic carbon to free iron and ratios of free iron plus aluminum to clay (C.S.S.C. 1978b). The generally high clay content of Fluviolacustrine material A plays an important role in classification of these horizons and soils. In imperfectly and poorly drained moisture regimes podzolic Bhf horizons, and the resultant Gleyed Ferro-Humic Podzols, are thought to be most abundant. Gleyed Humo-Ferric Podzols and Orthic Humic Podzols also occur under these conditions. Thin peaty surface horizons may or may not be present directly over the B horizon of over thin Ah or Ahe horizons.

Podzolic soils are associated primarily with morainal landforms, regardless of their drainage regime. Podzols in well drained moisture regimes also occur locally on colluvial, landslide, fluvial, ice contact stratified, and residual landforms, provided Eolian material B is present and surfaces are stable. The wetter Podzols occur locally on glaciolacustrine landforms in Banff. The landform materials may be either calcareous or noncalcareous. Podzolic soils occurring on calcareous materials frequently have a pH >5.5 within 25 cm from the top of the B horizon and are associated with Eutric and/or Melanic Brunisols.

THE CHERNOZEMIC ORDER

Steeply sloping, southerly-facing Montane and Subalpine grasslands and dry shrublands are dominated by Regosolic and Brunisolic soils with organo-mineral (Ah) surface horizons. The Ah horizons are of variable thickness but where they are 10 cm or more in thickness the soils have been mapped as Humic Regosols and Melanic Brunisols. There is some new evidence, based on data from our instrumented Mt. White grassland site (between Scotch Camp warden cabin and Snow Creek Pass), that some of these soils may, in fact, be Chernozemic.

Mean annual soil temperature from fall 1979 to fall 1980 was greater than 0°C for the instrumented pedon, which occurs at an elevation of nearly 2000 m. Morphological and chemical data for the pedon also support classification in the Chernozemic Order, specifically, the Orthic Dark Brown Subgroup. Depending upon the reliability of one year's temperature data and its extrapolation, Rego and Calcareous Dark Browns can also be expected. The pedon description and accompanying analyses for the instrumented grassland site are presented in the Wildflower 7 (WF7) Ecosite description, Chapter IV.

Steep, grassland and shrubland dominated slopes are common in the lower Athabasca River valley (Montane) and in several portions of the Front Ranges subprovince (Subalpine), particularly in eastern Banff. In the Front Ranges, there is a strong association with geomorphic materials derived from Mesozoic strata. Because the extent of Chernozemic soils on these slopes is thought to be of limited areal extent and the temperature data of these soils tentative, Chernozemic soils are not reflected in the Banff—Jasper Ecological Land Classification map legend.

THE CRYOSOLIC ORDER

Cryosolic soils represent the coldest soils found in Banff and Jasper. They have permafrost within 1 m and often within 50 cm of the ground surface. Cryosolic soils dominate many steep (30-70%), northerly-facing, forested slopes in the Front Ranges subprovince north of Banff townsite. They are confined primarily to morainal landforms consisting of medium textured, variably calcareous till derived from Mesozoic strata. Cryosolic soils occur in the Upper Subalpine from about 2200 m in Banff to as low as 1600 m in northern Jasper.

Regosolic Static Cryosols are most abundant. Their genesis is commonly influenced by solifluction which disrupts horizon development and mixes contrasting geomorphic materials in the active layer. Occasionally, buried organic and organo-mineral layers occur in the active layers, giving turbic phases. Orthic Static Cryosols occur on sites where the solifluction process is inconsequental. On a few undisturbed sites, altered, medium textured eolian material (Eolian material B) is present, resulting in yet thicker B horizons and soils classed as Brunisolic Static Cryosols. A feature common to these soils is the relatively thick (10-40 cm) organic layers (LFH horizons) mantling the mineral surface.

Cryosolic soils are generally imperfectly drained. However, a thin, saturated zone is frequently maintained at the frozen—unfrozen interface during thaw periods. This melt water usually seeps downslope over the frozen layer. Gley features are usually indistinct and partially masked by the inherently dark colored genetic material.

Gleyed Eutric Brunisols and, less frequently, Gleyed Cumulic Regosols are intimately associated with the Cryosolic soils. They occur along tract margins and in patches where permafrost is absent, probably only briefly during late summer. Gleyed Cumulic Regosols, like the Regosolic Static Cryosols, show the effects of solifluction.

Solifluction features, mainly lobes and benches, and a ragged, drunken forest appearance are common on landscape dominated by Cryosolic soils. They support stunted Engelmann spruce-subalpine fir forests, namely the Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/rock willow/white mountain heather (C24) v.t.s, with a nearly continuous feathermoss understory.

Achuff and Coen (1980) present data from a

Brunisolic Static Cryosol site on Mt. White in Banff. They recorded a mean annual permafrost temperature of -1.5°C at 100 cm and postulate that snow depth pattern throughout the year is particularly influential in maintaining the presence of permafrost. Distribution of Cryosolic soils on geomorphic material derived from Mesozoic strata suggests that some genetic material characteristics may also be important.

THE REGOSOLIC ORDER

Regosolic soils occur where active and recently active geomorphic processes of sufficient frequency and intensity inhibit pedogenic horizonation other than Ah horizon formation. They occur in all Ecoregions, on a variety of calcareous and noncalcareous geomorphic materials, on a variety of slopes, and under several different kinds of vegetation. Processes that modify landform surfaces and contribute to Regosolic soil maintenance are avalanching, soil creep, fluvial erosion and deposition, eolian deflation and deposition, windthrow of trees, sheet erosion, gully erosion, solifluction, and cryoturbation. Major landform building processes of recent age are also included. These are recent moraines, glaciofluvial floodplains, colluvial slopes, landslides, fluvial landforms, and eolian deposits. In some localities, shallow genetic materials overlying calcareous lithic layers also contribute to the occurrence of Regosolic soils.

Regosolic soils generally lack B horizons but in some localities may have thin (<5 cm) weakly developed Bm horizons. On actively eroding and aggrading sites, unaltered geomorphic material is often exposed at the surface. On some sites, thin organic layers and (under non-forested conditions) organo-mineral (Ah) horizons may develop. Regosolic soils of the Alpine, Alpine—Upper Subalpine ecotone, avalanched localities, grasslands, and dry shrublands frequently exhibit surface Ah horizons of varying thickness. In some cases, these horizons have been physically thickened by accretion of Ah material. Regosolic soils with surface Ah horizons <10 cm thick are classed as Regosols at the Great Group level (C.S.S.C. 1978b). In contrast Humic Regosols have surface Ah horizons 10 cm or more in thickness.

Cumulic Subgroups of these Great Groups generally have buried organic or organo-mineral horizons and, occasionally, buried B horizons. These indicate periods of relative stability followed by periods of genetic material accretion. In other cases, some geomorphic processes mix surface organic materials with subsurface mineral materials. Solifluction is a good example of such a process.

Regosolic soils are most often associated with Brunisolic soils under rapidly to moderately well drained conditions and where erosion and deposition have affected only portions of the landscape. On slopes characterized by grassland and dry shrubland, some of the soils classified as Humic Regosols may in fact be Rego Dark Browns in the Chernozemic Order as discussed previously. Under imperfectly to poorly drained conditions, Regosolic soils are often associated with Gleysolic and, less often, Organic soils. These are the Gleyed and Gleyed Cumulic Subgroups (C.S.S.C. 1978b). Evidence of gleying (i.e. dull colors and strong mottling) is only weakly expressed in the upper 50 cm of mineral soil.

THE GLEYSOLIC ORDER

Gleysolic soils occur under imperfectly to very poorly drained conditions on glacial, glaciolacustrine, fluvial, and fluviolacustrine landforms throughout all Ecoregions in Banff and Jasper. They generally occupy depressional landscape where seepage, surface water collection, and high water tables are important. A variety of moist to wet (hygric to hydric) vegetation is associated with Gleysolic soils.

Poorly aerated water saturates the soil for sufficiently long periods of time to result in reducing conditions. Manifestations of gleization are dull colors and/or strong mottling (C.S.S.C. 1978b). Gleysolic soils exhibit these features within 50 cm of the mineral surface. Rego Gleysols occur on sites where saturation is prolonged or where geomorphic activity has inhibited pedogenic horizonation. Orthic Gleysols, with B horizons, occur on stable sites where saturation periods are shorter or the seepage flow is more rapid and further from the surface.

Thin organic layers of moderately decomposed fen peat commonly mantle Gleysolic soils, except where mineral material is actively aggrading on fluvial, glaciofluvial, and fluviolacustrine landforms. Some Gleysolic soils also have thin organo-mineral (Ah) surface horizons. Rego Humic Gleysols and Orthic Humic Gleysols, with Ah horizons 10 cm or more thick, occur sporadically and are of minor importance on wetland areas.

Gleysolic soils are most often associated with gleyed Brunisolic, gleyed Podzolic, and Organic soils. Even though the gleyed Brunisolic and gleyed Podzolic soils occur under drainage regimes similar to those of the Gleysols, they often lack the mottling associated with intense reducing conditions.

THE ORGANIC ORDER

Organic soils occur most often in association with Gleysolic soils under poorly to very poorly drained conditions, primarily on glacial, fluvial, and fluviolacustrine landforms. The Organic members are the most poorly drained members of the association and are characterized by accumulation of 40 cm or more of primarily moderately decomposed organic material. Prolonged periods of ponding, with-

out mineral material sedimentation, and fen vegetation promote the accumulation of peat. Organic soils also occur on slopes of up to 15% where seepage is an important factor throughout much of the year.

The organic material is thought to be fen peat derived from sedges and brown mosses (e.g. *Tomenthypnum nitens* and *Aulacomnium palustre*), even though the fen vegetation has succeeded to open and closed forest in several areas. The peat is mainly moderately decomposed, hence the dominant Great Group is Mesisol. Subdominant humic and fibric layers and wood fragments also occur. Humic layers tend to be more common at low elevations, consequently Humisols occur sporadically in the Montane.

The peat accumulations rarely exceed 1.2 m in depth and the dominant Organic soils in Banff and Jasper are therefore Terric Mesisols. Thin mineral layers of fluvial and eolian origin are occasionally found included in lower portions of the organic layers. Underlying mineral materials are generally strongly gleyed.

METHODS OF SOIL DESCRIPTION AND ANALYSES

The necessary pedon and site information as suggested by Day et al. (1975) was recorded directly on computer coding forms using the procedures of Dumanski et al. (1975) and C.S.S.C. (1978a, b). The soils data and accompanying vegetation data were sorted and organized by computer as an aid to developing and refining the mapping legend.

FIELD EXAMINATION AND SOIL DESCRIPTION METHODS

The field work procedure involved initial stratification of the landscape by placing boundaries on aerial photographs followed by ground checking (field data collection) to refine map unit boundary locations and to corroborate interpretation of the landform, soil, and vegetation landscape components within map delineations. The observation sites were located on the aerial photographs as precisely as possible and pinpricks placed through the photograph so that locations could be annotated on the back with sample numbers. Thus, besides having UTM coordinates, each soil site (field checked and/or sampled) had an identified location on an aerial photograph. Field traverses were planned by examining the aerial photograhs and choosing a route that would verify the greatest number of map delineations and/or examine the delineations where the aerial photographic interpreter had questions requiring field verification.

Following ground checking and mapping procedures, various pedons were chosen to represent the soils of the Ecosites. These were described in detail on CanSIS forms and sampled for routine analysis in the laboratory.

CHEMICAL AND PHYSICAL ANALYTICAL METHODS

LABORATORY ANALYSES

Chemical and physical analyses were carried out after the samples were air dried and ground according to the routine procedures used by the Alberta Institue of Pedology (C.S.S.C. 1978c). These involved a determination of:

Soil Reaction; pH was determined with a pH meter using a 2:1 0.01 M $CaCl_2$ solution to soil ratio (Peech 1965).{3.11}[1]

Total Nitrogen; determined by the macro Kjeldahl-Wilforth-Gunning method (A.O.A.C. 1955). A mixture of HgO, $CuSO_4$, and K_2SO_4 (Kelpak) was used as a catalyst.

Calcium Carbonate Equivalent; inorganic carbon manometric method of Bascombe (1961).

Organic Carbon; by difference between total carbon and inorganic carbon. Total carbon was determined by dry combustion using an induction furnace (Allison et al. 1965) with a gasometric detection of evolved CO_2 (Leco model 577-100). {3.611}

Cation Exchange Capacity; by displacement of ammonium with sodium chloride (Chapman 1965) except that NH_4+ ion electrode is used to detect the displaced ammonium ion. {3.321}

Exchangeable Cations; extraction by neutral N NH_4OAC (A.O.A.C. 1955) with K, Mg, Na, and Ca determined by atomic absorption spectroscopy. {3.53, 3.531}

Sodium Pyrophosphate Extractable Iron and Aluminum; by McKeague (1967) method. The determination of Fe and Al was done by atomic absorption spectroscopy. {3.53,3.531}

Particle Size Distribution; by the pipette method of Kilmer and Alexander (1949) as modified by Toogood and Peters (1953), except that car-

[1]The numbers in {} indicate the method in C.S.S.C. (1978c).

bonates were not removed prior to dispersion.

Liquid limit, Plastic limit, and Plasticity Index; by the method outlined by ASTM (1970). {2.61, 2.62, 2.63}

One-third and fifteen Bar Moisture; by the pressure plate and pressure membrane methods (U.S. Salinity Laboratory Staff 1954). {2.44}

Bulk Density; by the soil clod method using Saran (C.S.S.C. 1978c). The samples were oven dried and weighed. Calculations were based on air dry volume. Values reported are the arithmetic mean of 3 to 5 determinations per horizon. {2.221}

FIELD TESTS

Percolation; by the method suggested by the Alberta Department of Manpower and Labour (1972). This consists of digging a hole to the depth of interest and saturation for 24 hours before measuring the rate of drop of the water level in the hole.

Infiltration; by the double ring method with a constant head apparatus as suggested by Adams et al. (1957).

CHAPTER III

VEGETATION

VEGETATION: INTRODUCTION AND METHODS . . . . . P. L. Achuff

VEGETATION TYPE DESCRIPTIONS I.G.W. Corns and P.L. Achuff

KEY TO VEGETATION TYPES .. P.L. Achuff

SUCCESSION AND CLIMAX . . .I. G. W. Corns and P. L. Achuff

SIGNIFICANT SPECIES..... P.L. Achuff and I.G.W. Corns

VEGETATION: INTRODUCTION AND METHODS

FIELD SAMPLING

One vegetation study objective was to provide vegetation resource data for integration into the Ecological Land Classification. The methods are therefore appropriate to the constraints of a 1:50,000 mapping program. Polygons of homogeneous composition were initially outlined on air photos. Selected polygons were then examined in the field. Single sample plots were established in areas representative of the predominant vegetation of the polygon. Each plot was located in a homogeneous area with avoidance of obvious ecotones, edge effects or environmental discontinuities (e.g. rock outcrops or drainage ways). Plots were generally 20 X 20 m in forested vegetation, 15 X 15 m in shrubby vegetation and 10 X 10 m in herbaceous and dwarf shrub vegetation. Smaller plots (5 X 5 m or 1 X 1 m) were sometimes necessary to keep the plot boundaries within a homogeneous area, as in some intricately patterned Alpine tundra.

Within each plot, canopy cover (Daubenmire 1959) was estimated to the nearest percent both for individual species and for each layer. Plants present with <1% cover were considered to have 0.5% cover. Epiphyte cover was not estimated; the species were merely noted as being present and all were assigned 0.5% cover. The layers recognized were: 1)Tree layer: woody plants >5 m tall. This layer was often divided into two layers where two tree height classes existed, 2)Tall Shrub layer: woody plants 2 to 5 m tall, 3)Low Shrub layer: woody plants 0.5 to 2 m tall, 4)Herb-Dwarf Shrub layer: woody plants <0.5 m tall and all herbs regardless of height, and 5)Bryoid layer: terrestrial lichens and bryophytes. Cover values were also estimated for ground litter (LFH), rocks and stones, exposed mineral soil, deadfall, and water. Usually, one of the largest trees in the plot was measured for height and diameter at breast height (dbh) and cored with an increment corer to determine its age. In addition, the average tree canopy height and the mean and range of dbh were estimated.

Physical environmental factors noted included: elevation, slope, aspect, topographic position, relief shape, landform, soil subgroup, and drainage class. Each plot was also rated on a moisture regime (hygrotope) scale (Table 7).

Voucher specimens were collected and are deposited in the herbaria of : Northern Forest Research Centre (CAFB), University of Alberta (ALTA), New York Botanical Garden (NY), Agriculture Canada (DAO), and the National Museum of Canada (CAN). Nomenclature for vascular plants follows primarily Moss (1959) and Hitchcock and Cronquist (1973), for hepatics Stotler and Crandall-Stotler (1977), for mosses Crum et al. (1973), and for lichens Hale and Culberson (1970) and Hawksworth et al. (1980).

CLASSIFICATION

The vegetation was classified initially into physiognomic classes: Closed Forest (C), Open Forest (O), Shrub (S), Low Shrub-Herb (L), and Herb-Dwarf Shrub (H). Closed Forests are those in which the distance between tree

Table 7 Ecological moisture regime clauses (Walmsley et al. 1980).

Class	Usual Soil Drainage
xeric - very dry, little precipitation or high evapotranspiration, very low available water storage capacity (AWSC)	very rapid
subxeric - dry, low AWSC	rapid
mesic - moist, intermediate to high AWSC	well to moderately well
subhygric - moist to wet, variable AWSC, seasonal seepage	imperfect
hygric - wet, variable AWSC, permanent seepage	poor
subhydric - wet, variable AWSC, excess water most of time	very poor
hydric - very wet, standing water constantly	-

crowns is not more than twice the mean crown diameter. This generally corresponds to a lower limit of tree cover of 15 to 20%. In Open Forests the distance between the crowns is 2X to 5X the mean crown diameter and tree cover is generally between 5% and 15 to 20%. Vegetation with <5% tree cover is not considered forested. Within these physiognomic classes, the classification is based primarily on stratal dominance (Whittaker 1973b) and characteristic combinations of species. Importance or dominance is determined by cover values and thus is a quantitative attribute. The vegetation samples are grouped on the basis of shared characteristics into abstract units called vegetation types (v.t.s). The v.t.s are viewed as "noda" (Poore 1962) along a vegetational gradient or "coenocline" (Whittaker 1967). The v.t. is of the same order of magnitude as the "association" of the Zurich-Montpellier approach (Westhoff and van der Maarel 1973) or the "biogeocoenose" of Sukachev (Sukachev and Dylis 1964), although the bases and methods of recognition differ. V.t.s were delineated by tabular comparison (Mueller-Dombois and Ellenberg 1974) and by both indirect ordination (Wisconsin ordination; Cottam, et al. 1974) and direct ordination (gradient analysis, Whittaker 1973a). Both seral and climax vegetation types were recognized. The plants used to name the v.t.s are usually layer dominants. A hyphen (-) separates species in the same layer; a virgule (/) separates layers.

ECOREGIONS

Vegetation is used as the basis for the definition of Ecoregions (Zones) in the Ecological Land Classification. Ecoregional divisions reflect macroclimate and thus, vegetation features, which reflect primarily climatic factors rather than for example edaphic factors, are used to define the Ecoregions. From low to high elevation, three Ecoregions are recognized: Montane, Subalpine and Alpine (Figs. 21, 22). Ecoregion is conceptually similar to the zone of Daubenmire (1968) and La Roi (1975), the biogeoclimatic zone of Krajina (1965) and Kojima (1981), the ecoregion of Strong and Leggat (1981), and the biophysical region of Lacate (1969). The Montane Ecoregion is characterized by v.t.s dominated by *Pseudotsuga menziesii*, *Picea glauca* and *Populus tremuloides* and by grasslands. Characteristic also is intermittant snow cover as a result of chinooks. Typical v.t.s include Douglas fir/hairy wild rye (C1), white spruce/fern moss (C2), lodgepole pine/juniper/bearberry (C3), aspen/hairy wild rye-peavine (C16) and junegrass-pasture sage-wild blue flax (H6). The altitude of the Montane Ecoregion ranges from the lowest elevations in the parks (about 1350 m in Banff and 1000 m in Jasper) to about 1600 m in Banff and 1350 m in Jasper. The boundary is slightly lower on northerly aspects and slightly higher on southerly aspects.

The Subalpine Ecoregion occurs at altitudes above the Montane Ecoregion and below the unforested Alpine Ecoregion. The Subalpine Ecoregion is further divided into Lower Subalpine and Upper Subalpine. The predominant vegetation of the Lower Subalpine is closed coniferous forest. Mature forest is dominated by *Picea engelmannii* and *Abies lasiocarpa*. Introgressive hybrids between *Picea engelmannii* and *Picea glauca* are common at lower altitudes of the Lower Subalpine. *Pinus contorta* forests are also common at lower altitudes. Typical v.t.s include lodgepole pine/buffaloberry/showy aster (C6), lodgepole pine/buffaloberry/twinflower (C19), Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/false azalea (C14). The upper altitudinal boundary of the Lower Subalpine is generally about 2000 m in Banff and 1900 m in Jasper.

The Upper Subalpine portion of the Subalpine Ecoregion is broadly ecotonal between Lower

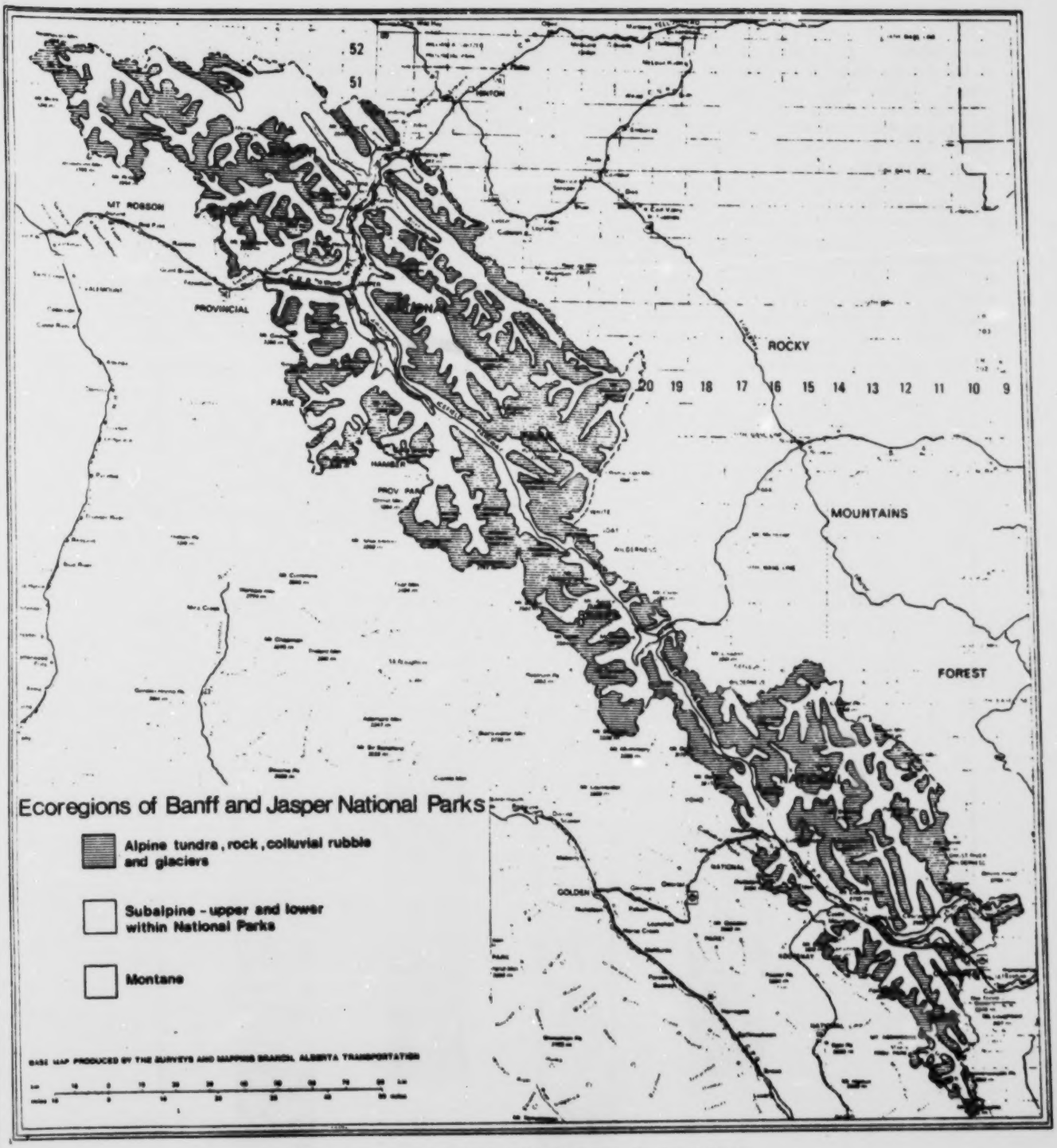


Figure 21 Ecoregions of Banff and Jasper National Parks.

Subalpine closed forest and treeless Alpine tundra. Compared to the Lower Subalpine, the Upper Subalpine climate is cooler and wetter, with greater snowfall, later snowmelt, and a shorter growing season. Greater wind speed also appears to be a significant climatic factor. Perhaps most characteristic are the open forests and stunted tree growth forms

(krummholz). The closed forests which occur in the Upper Subalpine typically contain some Alpine floristic elements, such as *Phyllodoce glanduliflora* in Engelmann spruce-subalpine fir/heather/feathermoss (C34) and occur at lower altitudes within the Upper Subalpine, often on warmer, southerly aspects. In the southern part of Banff, subalpine larch-subalpine fir/grouseberry-everlasting (C23) forests are characteristic of the Upper Subalpine. *Pinus contorta* is generally absent and forests are usually dominated by *Picea engelmannii* and *Abies lasiocarpa*. Typical v.t.s include Engelmann spruce-subalpine fir/heather (O10), Engelmann spruce-subalpine fir/valerian-fleabane (O9), Engelmann spruce-subalpine fir/grouseberry (C15) and Engelmann spruce-subalpine fir/rock willow/white mountain heather (C24). The upper altitudinal boundary to the Alpine Ecoregion is about 2300 m in Banff and 2200 m in Jasper.

The treeless Alpine Ecoregion occurs at elevations above the Upper Subalpine and reflects a cold, harsh climate. Alpine vegetation typically forms a complex, fine-scale mosaic in which microclimatic variations are reflected by marked changes in dominant species. Significant microclimatic factors include aspect, wind exposure, time of snowmelt, soil moisture, and snow depth. The most common v.t.s are heather-everlasting (L5) and mountain

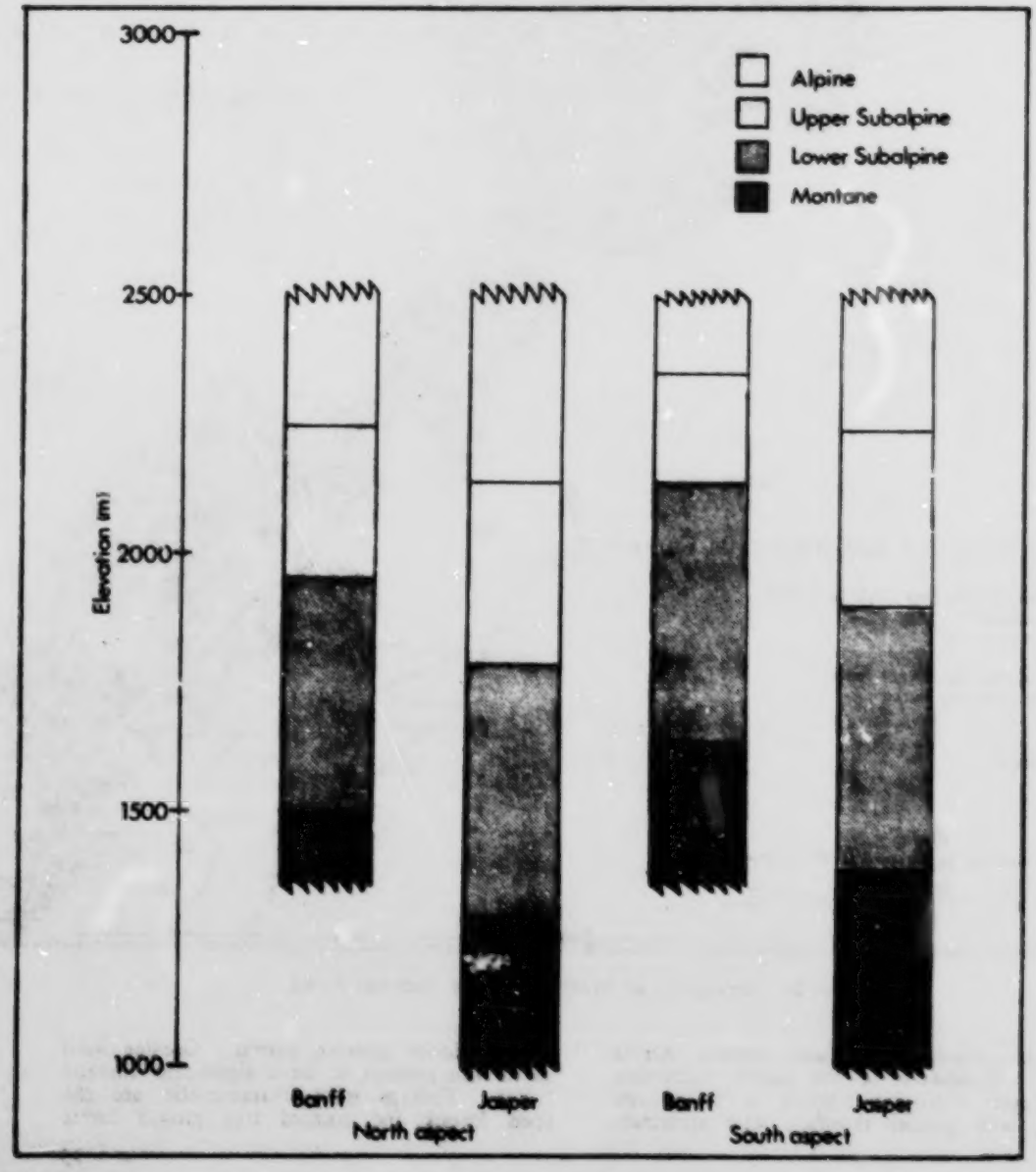


Figure 22 Elevation ranges of Ecoregion and Ecoregion subunits in Banff and Jasper National Parks.

avens-snow willow-moss campion (H1) in wind exposed sites and white mountain heather-mountain avens-snow willow (L4) in moderately deep snowbed sites. The highest altitude communities are usually saxicolous lichen (H12) on rocks and shallow soil.

VEGETATION TYPE DESCRIPTIONS

I.G.W. Corns and P.L. Achuff

C1: *Pseudotsuga menziesii/Elymus innovatus*

(Douglas fir/hairy wild rye)

Environment: The C1 v.t. occurs on subxeric mostly Montane sites (1150-1400 m J, 1300-1700 m B) on moderate to steep slopes and southerly aspects in the Bow River valley in Banff and the Athabasca River valley in Jasper. The soils are rapidly to well drained Eutric Brunisols and Regosols on colluvial and morainal landforms.

Vegetation: *Pseudotsuga menziesii* is the dominant canopy tree (Plate 6) with cover ranging from 15 to 70%, but usually 30 to 40% (Table 8). *Pinus contorta* and *Picea glauca* are often present with low cover in the tree layer. The shrub layer has a total cover of 10 to 25%, with *Juniperus communis* (1-15%), *Shepherdia canadensis* (1-5%), *Rosa acicularis* (<5%) and *Spiraea lucida* (≤5%) most common. *Elymus innovatus* (5-20%) and, in Banff, *Calamagrostis rubescens* (10-35%) dominate the herb-dwarf shrub layer. *Aster conspicuus* (5-10%) occurs frequently and *Fragaria virginiana*, *Achillea millefolium* and *Arctostaphylos uva-ursi* occur frequently but with cover usually <5%. The bryoid layer is sparse with small amounts of *Hylocomium splendens*, *Hypnum revolutum*, *Drepanocladus uncinatus*, and *Peltigera aphthosa*. Epiphytes are scarce with small amounts of *Letharia vulpina* usual.

The C1 v.t. is mature successionally with many stands 100 to 300 years old. *Pseudotsuga menziesii* regeneration of all size classes is commonly present indicating a self-perpetuating tree layer. Large, old *Pseudotsuga menziesii* with thick bark and several fire scars indicate that fires were a common occurrence in this type. Some stands were partially cut in the past.

The C1 v.t. differs from C5 in that C1 occurs on drier, often lower elevation sites, *Picea glauca* is not codominant in the tree layer, the shrub layer has greater cover, and the bryoid layer has little cover.

Other Studies: In Alberta, similar types have been described by Kondla (1978) in Kananaskis Provincial Park (Douglas fir/common juniper, Douglas fir/common juniper-buffaloberry), Jacques and Legge (1974) in the Kananaskis area (*Pseudotsuga menziesii/Calamagrostis rubescens-Elymus innovatus*), La Roi (1975) in Jasper (*Pseudotsuga menziesii/Elymus innovatus/Penstemon procerus/Cetraria islandica*), Stringer and La Roi (1970) in Banff (*Pseudotsuga menziesii/Calamagrostis rubescens-Elymus innovatus*) and Jasper (*Pseudotsuga menziesii/Elymus innovatus*), and Duffey (1971, Douglas fir) and Ogilvie(1971, Douglas fir) in the Porcupine Hills. The *Pseudotsuga menziesii/Elymus innovatus/Hylocomium splendens* type of LaRoi (1975) in Jasper is more mesic than most C1 stands. In central British Columbia, similar types have been described by Beil (1974, *Pseudotsuga menziesii/Calamagrostis rubescens*), Kuchar (1978) in Yoho National

Table 8 Stands representing the Douglas fir / hairy wild rye (C1) v.t.

	AN 50 30	AW 51 46	IC 80 14	IC 94 43	IC 70 01	JN 70 18	KS 50 03	KS 50 05	KS 50 36	KS 60 21
TREE LAYER										
Pinus contorta	05	01	--	05	07	02	--	--	--	--
Pseudotsuga menziesii	25	14	35	35	22	28	25	40	50	35
TALL SHRUB LAYER										
Pinus contorta	--	--	--	--	02	--	--	--	--	--
Pseudotsuga menziesii	--	01	--	--	02	01	--	05	--	03
SHRUB LAYER										
Juniperus communis	.5	.5	01	05	.5	02	--	08	.5	02
Picea glauca	--	.5	--	--	05	--	--	--	--	--
Pseudotsuga menziesii	--	02	--	--	--	--	--	01	.5	02
Rosa acicularis	09	01	01	03	01	02	02	01	03	.5
Shepherdia canadensis	10	01	03	03	08	01	--	01	--	04
Spiraea lucida	--	.5	01	.5	05	.5	--	--	05	03
HERB-DWARF SHRUB LAYER										
Achillea millefolium	.5	.5	--	--	.5	--	.5	01	01	02
Agropyron spp.	--	--	50	--	--	--	--	05	15	--
Agrostis spp.	--	--	--	--	--	--	--	--	10	--
Allium cernuum	--	.5	--	--	--	--	--	.5	03	02
Anemone multifida	--	.5	.5	--	--	--	--	--	.5	--
Antennaria nitida	--	01	--	--	--	--	.5	--	--	--
Antennaria rosea	--	--	--	--	--	--	--	--	.5	03
Arabis holboellii	--	--	.5	--	--	--	--	.5	--	.5
Arctostaphylos uva-ursi	02	02	01	.5	05	--	--	.5	--	--
Arnica cordifolia	02	--	.5	--	02	--	--	.5	--	--
Aster conspicuus	30	01	.5	02	05	07	05	10	05	06
Calamagrostis rubescens	40	22	--	--	--	--	15	10	--	35
Campanula rotundifolia	.5	--	--	--	--	--	--	--	.5	.5
Clematis verticellaris	--	--	--	--	--	--	.5	.5	02	--
Elymus innovatus	02	01	10	05	15	40	25	20	30	08
Erysimum inconspicuum	--	--	--	--	--	--	--	.5	.5	01
Fragaria virginiana	06	.5	.5	--	.5	04	.5	.5	.5	01
Galium boreale	--	.5	--	--	--	.5	.5	--	--	03
Lathyrus ochroleucus	--	--	.5	.5	01	.5	--	--	--	--
Linnaea borealis	01	--	.5	.5	03	05	--	--	--	--
Oxytropis spp.	.5	.5	--	--	--	--	01	03	.5	05
Penstemon confertus	--	--	--	--	--	--	--	--	01	.5
Pyrola secunda	.5	--	.5	--	.5	--	--	--	--	--
Vicia americana	--	--	.5	.5	.5	--	--	--	--	01
Viola adunca	--	.5	--	--	--	--	.5	--	--	--
BRYOID LAYER										
Ceratodon purpureus	--	--	.5	.5	--	.5	--	--	--	--
Cladonia spp.	--	--	.5	.5	01	--	--	--	--	--
Drepanocladus uncinatus	--	01	.5	.5	--	--	--	--	--	--
Hylocomium splendens	.5	--	01	--	.5	05	--	--	--	--
Hypnum revolutum	05	--	.5	.5	--	--	--	--	--	03
Peltigera aphthosa	01	01	.5	--	05	--	--	--	--	--
Peltigera canina	--	--	--	.5	01	--	--	--	--	02
Pleurozium schreberi	--	02	--	--	.5	03	--	--	--	--
Thuidium abietinum	--	--	.5	.5	--	--	30	--	--	--
Tortula ruralis	--	--	.5	.5	.5	--	--	--	--	15
EPIPHYTES										
Alectoria spp.	--	--	--	--	--	.5	--	--	--	--
Bryoria glabra	--	--	.5	--	--	--	--	--	--	--
Cetraria pinastri	--	--	.5	--	--	.5	--	--	--	--
Letharia vulpina	--	--	.5	--	--	--	--	.5	--	.5
Parmelia sulcata	--	--	.5	--	--	--	--	--	--	.5
Usnea spp.	--	--	--	--	--	.5	--	--	--	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Park (Douglas fir/pine grass-showy aster), Brayshaw (1965, *Pseudotsuga menziesii/Calamagrostis rubescens*, *Pseudotsuga menziesii/Arctostaphylos-Calamagrostis rubescens*), McLean (1970, Tisdale and McLean 1957, McLean and Holland 1958; *Pseudotsuga menziesii/Calamagrostis rubescens*), and Kujala (1945, *Pseudotsuga menziesii/Arctostaphylos-Calamagrostis*). Daubenmire and Daubenmire (1968) have described a *Pseudotsuga menziesii/Calamagrostis* type from northern Idaho and eastern Washington. In Montana, the *Pseudotsuga menziesii/Calamagrostis rubescens* type of Pfister et al. (1977) is similar, although floristic differences in nondominant species are apparent, and *Elymus innovatus* is absent.

C2: *Picea glauca/Thuidium abietinum*

(white spruce/fern moss)

Environment: The C2 v.t. occurs on mesic, Montane (1000-1300 m) sites of various slopes with northerly aspect, mostly in the east gate area of Jasper. The soils are well to rapidly drained Cumulic Regosols and Orthic Eutric Brunisols developed on highly calcareous eolian and fluvial landforms.

Vegetation: *Picea glauca* is the dominant tree (Plate 7) with 15 to 60% cover (Table 9). *Betula papyrifera* is occasionally present and *Pinus contorta* is usually absent. The shrub layer has generally <10% cover with *Rosa acicularis* (<5%) and *Shepherdia canadensis* (<3%) as the usual dominants. The cover of the herb-dwarf shrub layer is generally <10% but sometimes as high as 15%. Dominant species are *Elymus innovatus* (1-10%), *Linnaea borealis* (1-8%), and *Pyrola secunda* (<3%). *Clematis verticellaris* is present with low cover in most stands. The bryoid layer is dominated by the calciphile *Thuidium abietinum* (20-95%) and by *Hylocomium splendens* (<15%). Terrestrial and epiphytic lichens are scarce.

Successionally, C2 is advanced to mature with most stands 100 to 200 and occasionally 300 years old. *Pseudotsuga menziesii* is invading some sites or may be present as a relict of a previous stand.

The C2 v.t. is distinguished from C13 by the dominance in C2 of *Thuidium abietinum* rather than *Hylocomium splendens*. C2 differs from C26 and C27 in having a shrub layer with <5% cover and a sparse herb-dwarf shrub layer (Table 10). The C37 v.t. differs having well developed shrub and herb-dwarf shrub layers and *Hylocomium splendens* as the dominant bryophyte. Also, C37 occurs at elevations >1300 m where loessal veneers are shallow or absent. Intergrades between C2 and C26, C27 or C37 occur.

Table 9 Stands representing the white spruce / fern moss (C2) v.t.

	1C 80 37	1C 80 87	1C 81 01	1C 80 37	3C 70 88	3C 70 95	3S 70 81	3J 70 04	3J 70 06	3J 70 07
TREE LAYER										
Picea glauca	25	15	60	30	12	34	16	47	45	40
Pinus contorta	--	10	--	--	13	08	--	--	--	--
TALL SHRUB LAYER										
Picea glauca	--	--	--	--	25	.5	.5	--	08	05
Pinus contorta	10	--	--	--	05	--	--	--	--	--
SHRUB LAYER										
Amelanchier alnifolia	--	.5	.5	--	--	--	.5	--	--	--
Cornus stolonifera	--	--	01	--	--	--	01	--	--	--
Juniperus communis	.5	--	.5	--	--	02	.5	--	--	--
Lonicera dioica	--	--	01	--	--	.5	--	01	--	--
Picea glauca	--	--	--	--	05	.5	.5	--	--	--
Rosa acicularis	--	--	.5	--	02	08	02	03	05	03
Salix scouleriana	.5	--	--	--	--	--	.5	--	--	--
Shepherdia canadensis	.5	01	.5	--	01	01	03	--	04	02
Viburnum edule	--	.5	--	--	--	--	02	01	--	--
HERB-DWARF SHRUB LAYER										
Arctostaphylos uva-ursi	--	--	--	--	01	08	01	--	05	02
Aster ciliolatus	--	--	--	--	--	.5	01	--	--	.5
Aster conspicuus	--	--	--	--	01	--	.5	--	--	01
Carex concinna	.5	--	01	.5	--	01	.5	--	--	--
Carex eburnea	--	--	.5	--	--	--	--	--	.5	.5
Clematis verticellaris	.5	.5	--	--	--	--	.5	01	.5	--
Elymus innovatus	.5	01	.5	.5	03	25	05	01	05	15
Fragaria virginiana	--	01	.5	--	--	--	--	.5	--	.5
Galium boreale	.5	.5	.5	--	--	--	01	.5	--	.5
Geocaulon lividum	--	--	--	--	--	02	01	--	.5	.5
Hedysarum alpinum	--	--	.5	.5	--	--	01	--	.5	01
Hedysarum mackenzii	--	--	--	--	--	--	01	--	.5	.5
Linnaea borealis	.5	01	.5	02	08	40	01	01	10	--
Pyrola secunda	.5	.5	.5	--	.5	02	01	--	.5	--
Rosa acicularis	--	01	--	--	--	--	--	--	--	--
Zygodenus elegans	--	--	--	.5	.5	--	--	--	01	.5
BRYOID LAYER										
Cladonia pyxidata	--	--	--	--	.5	--	.5	--	--	--
Dicranum spp.	--	--	--	--	.5	02	--	--	--	--
Distichium capillaceum	--	--	--	--	.5	--	.5	--	.5	--
Ditrichum flexicaule	--	.5	--	--	.5	.5	.5	.5	--	--
Hylocomium splendens	01	15	--	15	15	20	.5	01	--	--
Hypnum revolutum	--	.5	--	--	--	.5	.5	.5	.5	.5
Hypnum spp.	--	--	01	.5	--	--	--	--	--	--
Peltigera aphthosa	.5	--	--	.5	--	--	--	--	--	--
Peltigera canina	--	--	--	--	--	--	.5	.5	.5	.5
Peltigera malacea	--	--	--	--	--	02	--	--	--	--
Peltigera spp.	--	.5	.5	--	--	--	--	--	--	--
Pleurozium schreberi	--	15	--	01	15	--	--	--	--	--
Pohlia nutans	--	.5	--	--	.5	--	--	--	--	--
Ptilium crista-castrensis	--	03	--	--	--	--	--	--	--	--
Rylaisiella polyantha	--	--	--	.5	--	.5	.5	--	--	--
Thuidium abietinum	90	50	20	65	50	60	60	65	60	07
Tortula ruralis	--	--	--	--	--	01	--	.5	--	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Other Studies: Dowding (1929) described similar forests in the Brule Lake area north of Jasper.

C3: *Pinus contorta/Juniperus communis/Arctostaphylos uva-ursi*

(lodgepole pine/juniper/bearberry)

Environment: The C3 v.t. occurs on subxeric to mesic, Montane to Lower Subalpine sites (1030-2000 m) on gentle to steep slopes of southerly and westerly aspect. The soils are rapidly to well drained Eutric Brunisols and Regosols on morainal, colluvial, fluvial, and glaciofluvial landforms.

Vegetation: *Pinus contorta* (15-40%) dominates the tree layer (Table 11, Plate 8). *Picea glauca* occurs frequently but with low cover (<5%). The moderately dense shrub layer (15-35%) is dominated by *Juniperus com-*

Table 10 A comparison of four *Picea glauca* v.t.s. showing dominant species by layer.

Veg. type	Tree layer	Shrub layer	Bryoid layer
C2	*Picea glauca*	<10% cover	*Thuidium abietinum*
C26	*Picea glauca*	>10% cover *Shepherdia canadensis*	*Thuidium abietinum*
C27	*Picea glauca*	>10% cover *Rosa acicularis*	*Thuidium abietinum*
C37	*Picea glauca*	>10% cover *Shepherdia canadensis*	*Hylocomium splendens*

munis (5-25%), *Shepherdia canadensis* (5-15%), and *Rosa acicularis* (1-3%). *Arctostaphylos uva-ursi* (10-25%) dominates the herb-dwarf shrub layer. *Linnaea borealis* (3-8%) and *Elymus innovatus* (5-15%) are also important. *Fragaria virginiana*, *Hedysarum sulphurescens* (in Banff), *Zygadenus elegans*, and *Solidago decumbens* occur with low cover but high frequency. Bryoid layer cover is low (<1-15%) with small amounts of *Drepanocladus uncinatus*, *Pleurozium schreberi*, *Hylocomium splendens*, and *Dicranum* spp. Epiphytes are sparse with *Letharia vulpina* most common.

Stand age is 75 to 200 years. Tree regeneration is preponderantly *Pinus contorta* and thus, it appears to be a climax species on these sites. The C3 v.t. is advanced to mature successionally.

The C3 v.t. is closely related to C6, C9, and C19 and intergrading stands occur. Table 12 compares C3 and four other *Pinus contorta* v.t.s. The C3 v.t. differs in having the herb-dwarf shrub layer dominated by *Arctostaphylos uva-ursi* rather than *Aster conspicuus* (C6), *Vaccinium caespitosum* (C9) or *Linnaea borealis* (C19). The C3 also has lower *Shepherdia canadensis* cover than C6 or C19, a subxeric moisture regime, and *Pinus contorta* regeneration.

Other Studies: Vegetation types similar to C3 have been described widely from the southern Yukon to northern Wyoming. In Alberta, similar types have been described by Ogilvie (1976, *Picea/Arctostaphylos*), Trottier and Scotter (1973) in Banff (*Pinus contorta/Juniperus communis-Arctostaphylos uva-ursi*), Lesko and Lindsay (1973) in the west central Alberta foothills (lodgepole pine/bearberry), La Roi (1975) in Jasper (*Pinus contorta/Juniperus communis/Elymus innovatus/Arctostaphylos uva-ursi/Brachythecium salebrosum*, *Pinus contorta/Shepherdia canadensis/Elymus innovatus/Arctostaphylos uva-ursi*), Hettinger (1975) in Jasper (*Pinus contorta* dominated stands of the *Pseudotsuga menziesii/Juniperus communis/Calamagrostis purpurascens* type), and La Roi and Hnatiuk (1980, *Pinus*

Table 11 Stands representing the lodgepole pine / juniper / bearberry (C3) v.t.

	AW 60 30	AW 70 86	IC 58 39	IC 58 96	IC 60 05	JC 71 20	KS 60 57	PA 71 80	PA 80 58	SJ 91 24
TREE LAYER										
Abies lasiocarpa	--	--	.5	--	--	--	--	--	--	--
Picea engelmannii	03	01	.5	--	--	--	--	05	05	02
Pinus contorta	10	41	30	15	35	22	33	35	30	21
TALL SHRUB LAYER										
Picea engelmannii	03	04	--	--	--	.5	--	02	.5	.5
Pinus contorta	04	--	--	--	--	03	--	08	--	01
SHRUB LAYER										
Amelanchier alnifolia	--	--	--	.5	.5	--	.5	--	--	02
Juniperus communis	15	20	04	05	03	25	10	10	20	20
Picea engelmannii	--	03	--	--	--	--	--	--	.5	01
Pinus contorta	--	--	--	--	--	04	--	--	--	10
Rosa acicularis	.5	--	01	01	01	01	01	05	.5	05
Shepherdia canadensis	03	02	07	15	08	08	.5	10	.5	15
Spiraea lucida	.5	--	--	02	--	02	.5	--	--	04
HERB-DWARF SHRUB LAYER										
Achillea millefolium	01	--	--	.5	.5	--	01	--	--	--
Anemone multifida	.5	--	--	--	--	--	01	--	--	.5
Antennaria racemosa	.5	--	01	01	--	--	--	--	--	--
Arctostaphylos uva-ursi	05	11	05	20	10	10	35	30	20	35
Arnica cordifolia	.5	--	02	--	--	--	--	--	--	--
Aster conspicuus	02	--	--	--	--	--	02	03	--	02
Aster sibiricus	--	--	--	--	--	--	02	--	--	--
Astragalus decumbens	--	--	--	--	--	--	05	--	--	--
Bromus pumpellianus	--	--	--	--	--	--	.5	05	--	--
Calamagrostis purpurascens	--	--	--	--	--	--	--	01	--	--
Calamagrostis rubescens	--	--	--	--	--	--	06	--	--	--
Calypso bulbosa	--	--	.5	--	.5	--	--	--	--	--
Campanula rotundifolia	--	--	.5	--	--	--	--	--	--	.5
Carex concinna	--	--	.5	--	--	01	--	--	02	--
Castilleja miniata	.5	--	01	--	.5	--	--	02	--	--
Elymus innovatus	02	.5	15	02	10	04	03	05	10	07
Epilobium angustifolium	--	--	.5	.5	.5	--	--	.5	--	--
Fragaria virginiana	01	--	--	.5	.5	--	01	--	--	02
Galium boreale	--	--	.5	--	--	.5	01	--	--	--
Hedysarum sulphurescens	--	--	--	--	--	--	18	05	03	--
Linnaea borealis	03	06	10	.5	10	02	--	.5	05	05
Pedicularis bracteosa	--	--	.5	--	--	--	--	--	--	--
Pyrola asarifolia	--	--	.5	--	--	.5	--	--	--	01
Pyrola secunda	--	.5	.5	--	--	.5	--	--	.5	01
Solidago decumbens	03	01	.5	.5	.5	--	.5	--	.5	01
Vaccinium myrtillus	--	02	--	--	--	--	--	--	--	--
Vaccinium scoparium	.5	05	--	--	--	--	--	--	--	--
Zygadenus elegans	--	02	.5	--	--	.5	--	.5	05	--
Cladonia mitis	--	--	--	.5	--	.5	--	--	--	--
Cladonia cariosa	--	--	--	--	--	--	--	--	--	.5
Cladonia coccifera	--	--	--	--	--	--	--	--	.5	--
Cladonia multiformis	--	--	--	--	--	--	--	--	10	--
Cladonia pyxidata	--	--	--	--	--	--	--	--	--	.5
Cladonia spp.	--	07	--	10	.5	--	--	--	--	--
Dicranum scoparium	--	--	--	--	--	--	--	--	15	--
Dicranum spp.	.5	04	--	.5	.5	01	--	--	--	--
Drepanocladus uncinatus	--	--	--	--	--	--	--	--	--	.5
Hylocomium splendens	--	--	.5	.5	25	36	--	--	--	--
Lophozia spp.	--	--	--	--	--	03	--	--	--	--
Peltigera aphthosa	--	--	--	--	01	01	--	--	--	.5
Peltigera canina	--	--	--	04	--	--	.5	--	--	--
Pleurozium schreberi	--	--	--	.5	20	10	--	--	--	--
Polytrichum commune	--	--	.5	--	.5	--	--	--	--	--
Polytrichum juniperinum	--	--	--	.5	--	--	--	--	--	--
Stereocaulon spp.	--	--	--	.5	.5	.5	--	--	--	--
EPIPHYTES										
Cetraria pinastri	--	--	--	--	--	--	.5	--	--	.5
Hypogymnia enteromorpha	--	--	--	--	--	--	--	--	--	.5
Letharia vulpina	--	--	--	--	--	.5	--	--	.5	--
Parmelia sulcata	--	--	--	--	--	.5	--	--	--	--
Usnea cornuligera	--	--	--	--	--	--	--	--	--	--
Usnea spp.	--	--	--	--	--	.5	--	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Table 12 A comparison of five *Pinus contorta* v.t.s.

Veg. type	Moisture regime	Altitude (m)	Species and percent cover values: *Shepherdia canadensis*	*Juniperus communis*	*Arctostaphylos uva-ursi*	*Linnaea borealis*	*Aster conspicuus*	*Vaccinium scoparium*	Tree regeneration
C3	subxeric	1030-2000	5-15	5-25	10-25	3-8	<1	-	*Pinus*>*Picea*
C6	mesic	B1400-1800 J1150-1720	15-30	1-5(10)	1-3(5)	3-5	10-20	<1	*Picea*>*Pinus*
C9	mesic-subxeric	1400-1750	1-6	1-3	2-6	5-10	<1	<1 (*V. caespitosum* 10-25%)	*Picea*
C18	mesic	1500-2020	10-30	1-5	1-2	3-10	<1	20-45	*Picea*>*Pinus*
C19	mesic	1200-2000	10-30	1-3	1-3	10-25	<1	-	*Picea*>*Pinus*

contorta/Shepherdia canadensis/Arctostaphylas uva-ursi) in Banff and Jasper. Mackenzie-Grieve (1970) described similar *Pinus-Populus/Shepherdia-Arctostaphylos* vegetation from the Red Deer River area east of Banff. In British Columbia, similar types have been described by Wali and Krajina (1973, *Cladonio (gracilis)-Arctostaphylo (uvae-ursi)-Vaccinio (myrtilloidis)-Pinetum contortae*), Illingworth and Arlidge (1960, *Pinus contorta/Calamagrostis-Arctostaphylos*, *Pinus contorta/Arctostaphylos*-lichen), Raup (1934, dry pine woods), Beil (1974, *Pinus contorta/Calamagrostis rubescens*), Brayshaw (1965, *Pinus contorta/Arctostaphylos-Calamagrostis rubescens*), and Kujala (1945, *Pinus contorta/Arctostaphylos-Calamagrostis*). Orloci and Stanek (1979) described a *Pinus-Arctostaphylos-Festuca* type from the southern Yukon. Hoffman and Alexander (1976) described a *Pinus contorta/Arctostaphylos uva-ursi* type from northern Wyoming.

C4: *Picea glauca/Rosa acicularis/Equisetum arvense*

(white spruce/prickly rose/horsetail)

Environment: The C4 v.t. occurs on subhygric to hygric sites mostly in the Montane Ecoregion (usually <1500 m; 1000-1330 J , to 1530 B) on gentle slopes of various aspects in Banff and Jasper. The soils are imperfectly to poorly drained Gleysolics, Regosolics, and Organics on fluvial landforms.

Vegetation: This closed forest type has a tree layer with 20 to 55% cover composed almost entirely of *Picea glauca* (Table 13). The shrub layer is well developed (10-35% cover) and is dominated by *Rosa acicularis* (5-15%) with lesser amounts of *Cornus stolonifera* (3%) and *Alnus tenuifolia* (5%) in Jasper and of *Ribes lacustre* (1%) in Banff. Herb-dwarf shrub cover is 35 to 70% with *Equisetum arvense* (30-50%) dominant (Plate 9). Also of common occurrence are *Equisetum pratense* (5-15%), *Linnaea borealis* (5%), *Mitella nuda* (1%), *Equisetum scirpoides* (5%), and *Pyrola secunda* (<1%). Bryoid cover is 20 to 60% with *Hylocomium splendens* (15-50%) dominant. Ground lichens and epiphytes are sparse.

Table 13 Stands representing the white spruce / prickly rose / horsetail (C4) v.t.

	1C 60 33	JC 70 21	JD 80 23	JH 70 06	JN 70 12	JP 81 19	KS 50 01	KS 51 58	KS 60 22	KS 60 69
TREE LAYER										
Abies lasiocarpa	--	42	--	--	--	--	--	--	--	--
Picea glauca	65	20	25	23	20	39	45	60	55	60
Populus balsamifera	--	.5	--	02	--	01	.5	--	--	--
TALL SHRUB LAYER										
Picea glauca	--	.5	.5	--	--	.5	--	10	10	05
SHRUB LAYER										
Cornus stolonifera	01	--	--	02	01	01	--	.5	--	--
Lonicera dioica	--	--	--	.5	.5	.5	--	--	--	--
Lonicera involucrata	03	.5	--	--	--	.5	01	02	05	.5
Picea glauca	--	--	.5	--	--	.5	.5	10	03	03
Populus balsamifera	--	--	--	01	--	--	01	.5	.5	08
Ribes lacustre	--	--	--	--	--	--	01	.5	02	01
Rosa acicularis	01	03	01	01	05	01	03	10	02	20
Salix spp.	.5	--	05	--	.5	--	--	07	--	02
Shepherdia canadensis	--	.5	--	--	02	.5	--	--	--	10
Viburnum edule	--	04	--	--	.5	--	--	02	01	--
HERB-DWARF SHRUB LAYER										
Aster ciliolatus	--	--	.5	--	--	.5	--	--	--	--
Carex concinna	--	--	--	--	--	.5	.5	--	.5	.5
Carex vaginata	--	--	03	--	.5	--	--	--	02	--
Cornus canadensis	07	06	--	--	--	--	--	--	03	08
Epilobium angustifolium	.5	.5	.5	--	--	--	--	--	.5	02
Fragaria virginiana	--	--	.5	--	--	.5	--	.5	--	04
Geocaulon lividum	--	04	--	--	02	--	--	01	--	--
Habenaria obtusata	--	--	.5	--	--	--	--	02	.5	--
Linnaea borealis	10	06	01	--	01	01	--	02	.5	10
Mitella nuda	01	.5	--	--	.5	--	--	10	06	--
Petasites palmatus	07	--	02	--	--	--	.5	--	--	10
Petasites sagittatus	--	--	01	--	--	--	--	01	--	--
Petasites vitifolius	--	--	--	--	--	--	01	--	18	--
Pyrola asarifolia	--	--	--	--	--	.5	--	02	.5	--
Pyrola secunda	.5	.5	--	--	--	01	--	06	.5	--
Rubus pubescens	.5	--	--	--	--	.5	02	--	02	--
Senecio lugens	--	--	.5	--	--	--	--	04	--	02
Smilacina stellata	--	--	--	--	.5	.5	--	--	02	--
Equisetum arvense	50	20	80	30	.5	67	--	40	50	40
Equisetum pratense	.5	--	--	--	--	.5	--	20	15	02
Equisetum scirpoides	--	--	.5	--	--	.5	--	06	08	10
BRYOID LAYER										
Aulacomnium palustre	--	--	30	--	--	--	--	--	30	.5
Cladonia spp.	--	.5	.5	.5	--	--	--	--	--	--
Bryoerythrophyllum recurvirostrum	--	--	--	.5	--	--	.5	--	--	--
Drepanocladus uncinatus	--	--	.5	.5	--	--	--	20	--	--
Hylocomium splendens	60	40	85	.5	--	--	--	30	40	50
Hylum spp.	--	--	01	--	--	--	35	.5	10	--
Peltigera aphthosa	03	.5	.5	.5	--	--	--	--	--	02
Peltigera canina	--	--	--	--	--	01	--	--	--	--
Pleurozium schreberi	30	40	--	--	--	--	--	20	--	15
Ptilium crista-castrensis	05	02	--	--	--	--	--	--	--	.5
Pylaisiella polyantha	--	--	--	.5	.5	.5	--	--	--	--
Rhytidiadelphus triquetrus	02	.5	--	--	--	--	--	--	--	--
Thuidium abietinum	--	--	--	40	07	65	--	.5	--	--
EPIPHYTES										
Alectoria spp.	--	--	-	--	--	--	--	--	.5	.5
Hypogymnia physodes	--	.5	--	--	--	--	--	--	--	--
Letharia vulpina	--	--	--	--	--	--	--	--	--	.5
Parmelia sulcata	--	.5	--	--	--	.5	--	--	--	--
Parmeliopsis ambigua	--	.5	--	.5	--	--	--	--	--	--
Parmeliopsis hyperopta	--	--	--	.5	--	.5	--	--	--	--
Usnea spp.	--	--	.5	--	--	--	--	.5	.5	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The C4 v.t. is mature successionally with stands 100 to 225 years old. *Picea glauca* regeneration is common in the shrub layers.

The C4 v.t. is similar to C32, but can be distinguished by occurring on wetter, generally Montane (<1500 m) sites, by having a denser shrub layer dominated by *Rosa acicularis, Cornus stolonifera*, and *Alnus tenuifolia*, and by the usual absence of *Arnica cordifolia, Elymus innovatus*, and *Mertensia paniculata*.

Other Studies: Similar vegetation (floodplain spruce forests) was described in northern Alberta and southern Northwest Territories along the Peace, Slave, and Mackenzie rivers by Raup (1934, 1946, 1947) and in the Alberta foothills by Lesko and Lindsay (1973, white spruce/horsetail association). In the Alberta Rocky Mountains, similar vegetation was described for Jasper by La Roi (1975, *Picea glauca-Picea mariana/Lonicera involucrata/Equisetum arvense/Equisetum scirpoides/Hylocomium splendens*), Kuchar (1972, lowland white spruce forest) and for Banff and Jasper by Ogilvie (1976, *Picea/Equisetum* association), and Beil (1974, *Picea glauca/Equisetum arvense*). Kuchar (1978) described a similar spruce/horsetail type in Yoho National Park and Pfister et al. (1977) encountered similar forests (*Picea/Equisetum arvense*) in Montana.

C5: *Picea glauca-Pseudotsuga menziesii/Hylocomium splendens*

(white spruce-Douglas fir/feathermoss)

Environment: The C5 v.t. occurs on mesic, Montane to Lower Subalpine sites (1250-1650 m) on various slopes and northerly aspects along the Athabasca River in Jasper and along the Bow River and Lake Minnewanka in Banff. The soils are well drained Orthic Eutric Brunisols, Regosols, and Brunisolic Gray Luvisols on fluvial and morainal landforms.

Vegetation: The tree layer is dense (Plate 10) and composed of *Picea glauca* (20-40%) and *Pseudotsuga menziesii* (20-40%) often in approximately equal amounts (Table 14). The shrub layer is sparse (<10%) with *Rosa acicularis* and *Shepherdia canadensis* having low cover but high frequency. The herb-dwarf shrub layer is also sparse (≤10%) and usually contains *Pyrola secunda* (<1%), *Linnaea borealis* (<5%), *Aster conspicuus* (<5%), *Cornus canadensis* (<5%), and *Elymus innovatus* (<3%). The bryoid layer has high cover (50-90%) and is dominated by *Hylocomium splendens* (30-75%) and *Peltigera aphthosa* (3-5%) with lesser amounts of *Pleurozium schreberi, Ptilium crista-castrensis, Drepanocladus uncinatus*, and *Peltigera canina*. Epiphytes are in moderate abundance with *Letharia vulpina* and *Parmelia sulcata* common.

Table 14 Stands representing the white spruce / Douglas fir / feathermoss (C5) v.t.

	IC 50 51	IC 50 55	IC 60 69	JC 80 02	KB 60 20	PA 70 10	PA 70 11	PA 81 65	SJ 70 27	SJ 70 28
TREE LAYER										
Abies lasiocarpa	01	05	--	--	--	--	--	--	05	10
Picea glauca	15	40	20	30	50	30	25	35	20	15
Pinus contorta	15	--	--	05	--	.5	05	--	01	05
Pseudotsuga menziesii	20	03	20	35	30	15	05	25	.5	25
TALL SHRUB LAYER										
Abies lasiocarpa	--	--	--	--	--	--	--	--	01	15
Picea glauca	--	--	10	01	03	--	--	.5	01	--
Pseudotsuga menziesii	--	--	--	01	--	--	--	.5	.5	--
SHRUB LAYER										
Picea glauca	--	--	05	--	--	--	.5	.5	--	--
Ribes lacustre	--	.5	--	--	--	--	.5	--	--	.5	.5
Rosa acicularis	02	--	--	.5	.5	01	01	03	02	--
Shepherdia canadensis	05	.2	.5	--	--	--	.5	.5	03	--
HERB-DWARF SHRUB LAYER										
Arnica cordifolia	20	--	--	--	--	--	01	--	02	02
Aster conspicuus	--	--	--	01	02	01	02	.5	02	--
Corralorhiza trifida	--	--	--	--	--	.5	.5	.5	--	--
Cornus canadensis	20	--	--	--	05	01	02	--	02	--
Elymus innovatus	03	.5	--	--	--	--	--	.5	01	.5
Epilobium angustifolium	.5	--	--	.5	--	--	--	--	.5	--
Fragaria virginiana	.5	--	--	--	--	--	--	--	.5	--
Juniperus communis	02	02	--	.5	--	--	--	15	--	--
Linnaea borealis	05	01	--	01	08	01	--	10	03	02
Mitella nuda	--	--	--	--	--	.5	.5	--	--	.5	.5
Pyrola secunda	05	.5	.5	.5	02	.5	.5	.5	01	--
Pyrola virens	.5	.5	--	--	.5	--	--	--	--	--
BRYOID LAYER										
Bryoerythrophyllum recurvirostrum	.5	--	--	.5	--	--	--	--	--	--
Cetraria nivalis	--	--	--	--	--	--	.5	--	.5	--
Cladonia spp.	.5	--	--	.5	--	--	--	--	.5	.5
Drepanocladus uncinatus	.5	--	02	--	--	.5	--	--	--	.5
Hylocomium splendens	15	98	70	45	90	30	30	60	85	60
Hypnum revolutum	.5	.5	--	02	.5	--	--	15	--	--
Orthotrichum spp.	--	--	--	.5	--	--	--	.5	.5	--
Peltigera aphthosa	01	--	03	03	03	05	05	10	02	04
Peltigera canina	.5	--	--	--	02	.5	--	.5	04	01
Pleurozium schreberi	05	.5	--	--	--	25	30	--	--	.5
Pohlia nutans	.5	--	--	.5	.5	.5	--	--	--	--
Ptilium crista-castrensis	--	.5	--	--	--	30	25	--	01	.5
Thuidium abietinum	--	--	--	01	02	--	--	05	--	--
Timmia austriaca	--	--	--	--	.5	--	--	--	.5	01
EPIPHYTES										
Cetraria pinastri	.5	--	--	--	--	.5	--	--	.5	.5
Hypogymnia spp.	.5	--	--	.5	--	.5	.5	.5	.5	.5
Letharia vulpina	--	--	--	--	.5	--	.5	.5	--	.5
Parmelia spp.	--	.5	--	.5	--	.5	--	--	.5	.5
Usnea spp.	.5	.5	--	.5	--	.5	--	.5	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Successionally, C5 is mature with stands 100 to 300 years old.

The C5 v.t. differs from C1 in occurring on more mesic sites often at higher elevation, the shrub layer has less cover (<10%) and the bryoid layer, especially *Hylocomium splendens*, has greater cover.

Other Studies: Kuchar (1978) described a similar white spruce-Douglas fir forest from Yoho National Park in British Columbia. A related type (moss association) is described from southern British Columbia by Bell (1965) but has *Tsuga heterophylla* instead of *Picea glauca* codominant with *Pseudotsuga menziesii*.

C6: *Pinus contorta/Shepherdia canadensis/Aster conspicuus*

(lodgepole pine/buffaloberry/showy aster)

Environment: The C6 v.t. occurs on mesic Montane to Lower Subalpine sites (1400-1800 m B, 1150-1720 m J) on moderate slopes of southerly and westerly aspect. The soils are well to rapidly drained Eutric Brunisols, Regosols, and Brunisolic and Orthic Gray Luvisols on morainal, fluvial, colluvial, and glaciofluvial landforms.

Vegetation: The tree layer is closed (30-55%) and dominated by *Pinus contorta* (25-45%) (Table 15). *Picea* spp. are also often present with cover ≤10%. The moderately dense shrub layer (20-40%)(Plate 11) is dominated by *Shepherdia canadensis* (15-30%). Other common shrubs are *Juniperus communis* (1-5%), *Rosa acicularis* (10-20%) and *Spiraea lucida* (1%). The herb-dwarf shrub layer, with a total cover of 40 to 60%, is dominated by *Aster conspicuus* (10-20%) and *Elymus innovatus* (10-15%), or *Calamagrostis rubescens* (10-20%) in some Banff stands. *Linnaea borealis* (3-5%), *Arnica cordifolia* (1-5%), and *Arctostaphylos uva-ursi* (1-3%) are common and *Pyrola secunda*, *Fragaria virginiana* and *Epilobium angustifolium* occur with high frequency but low cover. The bryoid layer has a total cover of 30 to 60% and is dominated by *Hylocomium splendens* (10-30%), *Pleurozium schreberi* (10-25%), and *Peltigera aphthosa* (1-3%). Epiphytes are scarce with *Letharia vulpina*, *Alectoria* spp., and *Usnea* spp. most common.

Stands in C6 are mostly 60 to 100 years old and of fire origin. Tree regeneration is mostly *Picea* spp. and C6 is intermediate to advanced successionally. Successional development to C31, C13, or C37 appears likely.

The C6 v.t. is closely related to C3, C18, and C19 and intergrading stands occur. Table 12 compares C6 and four other *Pinus contorta* v.t.s. The C6 v.t. differs from the other v.t.s in having the herb-dwarf shrub layer dominated by *Aster conspicuus* rather than *Linnaea borealis* (C19), *Vaccinium scoparium* (C18), or *Arctostaphylos uva-ursi* (C3). The C3 v.t. also differs from C6 in having lower *Shepherdia canadensis* cover, higher *Juniperus communis* cover, and *Pinus contorta* regeneration rather than *Picea* spp.

Other Studies: Similar forests were described for Alberta by Kirby and Ogilvie (1969) in the Kananaskis area (young *Pinus contorta/Hylocomium-Cornus* type) and by Kondla (1978) also for the Kananaskis area (pine/buffaloberry-feathermoss type). Cormack (1953) in the southern Alberta foothills described similar forests as seral to spruce-fir climax. In Banff, Ogilvie (1976) described a similar pine dominated *Picea-Abies/Calamagrostis* type and in Jasper Hettinger (1975) described similar vegetation as seral to a *Pseudotsuga menziesii/Elymus innovatus* type. La Roi (1975) also described a similar type in Jasper (*Pinus contorta/Shepherdia canadensis/Rosa acicularis/Arnica cordifolia/Linnaea borealis/Pleurozium schreberi*). In Banff and Jasper, La Roi and Hnatiuk (1980) described a similar *Pinus contorta/Shepherdia canadensis/Elymus innovatus* type. Similar types have been de-

Table 15 Stands representing the lodgepole pine / buffaloberry / showy aster (C6) v.t.

	AW	IC	IC	JC	JC	JD	KS	LC	PA	PA
	68	56	80	70	71	70	50	90	70	81
	62	42	65	13	18	28	81	26	14	41
TREE LAYER										
Picea engelmannii	.5	--	06	--	--	--	--	--	--	--
Picea glauca	--	01	--	08	01	--	03	10	--	--
Pinus contorta	35	45	39	40	45	45	55	25	63	50
Populus tremuloides	--	--	--	--	--	--	--	05	02	--
Pseudotsuga menziesii	--	--	--	--	--	--	--	10	--	--
TALL SHRUB LAYER										
Abies lasiocarpa	--	--	.5	--	--	--	--	--	--	--
Picea engelmannii	--	--	10	--	--	01	--	--	--	--
Picea glauca	--	--	--	--	04	--	10	08	--	--
Pinus contorta	--	--	.5	--	--	.5	--	--	--	.5
Pseudotsuga menziesii	--	--	--	--	--	--	--	07	--	--
Shepherdia canadensis	--	--	--	.5	--	--	--	--	--	--
SHRUB LAYER										
Abies lasiocarpa	--	.5	.5	--	--	--	--	--	--	--
Alnus crispa	--	--	.5	--	.5	--	--	--	--	--
Amelanchier alnifolia	--	--	--	--	05	--	--	.5	--	--
Juniperus communis	06	.5	01	--	--	15	.5	15	.5	.5
Ledum groenlandicum	--	--	02	--	--	--	--	--	--	--
Picea glauca	--	--	--	--	--	.5	.5	10	05	--
Pinus contorta	.5	--	--	--	.5	.5	--	--	--	--
Pseudotsuga menziesii	--	--	--	--	--	--	--	05	--	--
Rosa acicularis	01	.5	01	02	03	.5	--	03	02	05
Shepherdia canadensis	35	10	45	18	10	40	35	20	10	40
Spiraea lucida	--	.5	--	--	02	--	--	05	--	01
HERB-DWARF SHRUB LAYER										
Achillea millefolium	--	--	.5	--	--	--	--	.5	--	--
Arctostaphylos uva-ursi	04	03	05	--	03	10	--	--	--	.5
Arnica cordifolia	06	05	02	01	--	01	10	04	15	.5
Aster conspicuus	09	15	10	05	03	20	12	05	10	20
Calamagrostis rubescens	09	15	10	05	03	20	12	05	10	20
Calypso bulbosa	--	--	--	--	--	--	--	01	.5	--
Castilleja miniata	02	.5	.5	.5	--	--	--	--	--	--
Clematis verticellaris	--	--	--	--	--	--	--	01	01	--
Cornus canadensis	--	01	01	02	03	--	08	.5	--	--
Elymus innovatus	25	07	15	10	20	30	15	08	30	15
Epilobium angustifolium	.5	--	.5	.5	01	--	08	--	.5	02
Fragaria virginiana	.5	--	01	--	--	.5	03	01	.5	05
Habenaria obtusata	--	.5	.5	.5	--	--	--	--	--	--
Hedysarum sulphurescens	01	--	--	--	--	--	--	--	--	.5
Lathyrus ochroleucus	--	--	01	01	--	--	06	--	02	.5
Linnaea borealis	11	05	15	05	02	15	25	07	02	15
Pyrola asarifolia	--	.5	.5	01	.5	--	02	--	.5	--
Pyrola secunda	.5	.5	.5	01	.5	.5	03	.5	01	02
Pyrola virens	01	.5	--	--	--	.5	--	--	--	--
Stenanthium occidentale	--	--	--	--	--	--	03	--	.5	--
Vicia americana	--	--	.5	.5	--	--	06	--	--	--
BRYOID LAYER										
Brachythecium salebrosum	--	--	--	--	--	--	--	--	.5	10
Brachythecium velutinum	--	--	--	--	--	--	--	--	.5	.5
Brachythecium spp.	--	--	.5	.5	01	--	--	--	--	.5
Ceratodon purpureus	--	.5	--	.5	--	--	--	--	--	--
Cladonia gracilis	--	--	.5	--	--	--	--	--	--	--
Cladonia mitis	--	--	--	--	.5	--	--	--	--	--
Cladonia phyllophora	--	.5	.5	--	--	--	--	--	--	--
Cladonia pyxidata	--	.5	--	.5	--	--	--	--	--	--
Cladonia spp.	02	.5	--	--	01	.5	--	.5	.5	.5
Dicranoweisia crispula	--	.5	--	--	--	--	--	--	--	--
Dicranum fuscescens	--	--	--	.5	--	--	--	--	.5	--
Distichium capillaceum	--	--	--	.5	.5	--	--	--	--	--
Ditrichum flexicaule	--	.5	--	--	--	.5	--	--	--	--
Drepanocladus uncinatus	01	.5	--	.5	--	05	--	--	.5	10
Eurhynchium pulchellum	--	--	--	.5	.5	--	--	--	--	--
Hylocomium splendens	--	05	25	60	07	30	30	40	10	.5
Peltigera aphthosa	--	--	01	--	01	.5	--	--	.5	05
Peltigera canina	04	--	--	.5	--	.5	--	--	--	.5
Peltigera rufescens	--	.5	--	--	--	--	--	--	.5	.5
Pleurozium schreberi	02	02	10	--	30	--	25	05	04	15
Polia nutans	--	--	.5	--	--	.5	--	--	.5	--
Ptilium crista-castrensis	--	.5	--	--	01	--	03	05	.5	.5
EPIPHYTES										
Alectoria spp.	--	--	--	--	.5	--	--	.5	--	--
Bryoria glabra	--	--	--	--	--	--	--	--	.5	.5
Cetraria pinastri	--	.5	.5	--	.5	--	--	--	--	.5
Hypogymnia austerodes	--	.5	--	--	.5	--	--	--	--	.5
Hypogymnia physodes	--	--	--	--	.5	--	--	--	.5	--
Letharia vulpina	.5	--	--	--	.5	--	--	--	.5	.5
Parmelia sulcata	--	--	--	--	.5	--	--	--	.5	.5
Usnea sorediifera	--	--	.5	--	--	--	--	--	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

scribed in British Columbia by Kuchar (1978) in Yoho National Park (lodgepole pine/buffaloberry/pinegrass), Tisdale and McLean (1957) in central British Columbia (*Pinus/Calamagrostis*), and by Illingworth and Arlidge (1960) in south central British Columbia *(Pinus contorta/ Calamagrostis).*

C8: *Picea mariana-Pinus contorta/Salix myrtillifolia/Carex vaginata*

(black spruce-lodgepole pine/willow/sedge)

Environment: The C8 v.t. occurs on hygric Montane to Lower Subalpine sites (1230-1700 m) on level to gently sloping northerly aspects in Jasper and northern Banff. The soils are Gleysolics and Organics occurring on morainal landforms.

Vegetation: The tree layer is closed (20-50%)(Plate 12) and is dominated by *Picea mariana* (10-40%) and *Pinus contorta* (5-10%)(Table 16). The shrub layer has a total cover of 20 to 40% and includes *Salix myrtillifolia* (5-10%) and *Ledum groenlandicum* (5-20%). The herb-dwarf shrub layer has 15 to 40% cover and is dominated by *Carex vaginata* (2-5%), *C. capillaris* (1%), and *Arctostaphylos rubra* (3%). *Petasites palmatus, Equisetum arvense, E. scirpoides,* and *Linnaea borealis* have cover ≤1% but high frequency. The bryoid layer covers 50 to 75% of the hummocky ground surface. Important species are *Aulacomnium palustre* (5-30%) and *Tomenthypnum nitens* (5%) in wetter microsites, and *Hylocomium splendens* (10-50%) and *Pleurozium schreberi* (5-20%) in drier microsites on hummock tops. *Peltigera aphthosa* is common but with cover <1%. Epiphytes are generally scarce.

Stands are 100 to 150 years old. *Picea mariana* regeneration is common and C8 is advanced to mature successionally.

The closed tree canopy and the occurrence of *Pinus contorta* in C8 distinguish it from O11.

Other Studies: Laidlaw (1971) described a similar type (*Picea mariana-Pinus contorta/ Ledum groenlandicum-Salix* spp./*Carex* spp./ *Ditrichum flexicaule*) from Jasper.

C9: *Pinus contorta/Vaccinium caespitosum*

(lodgepole pine/dwarf bilberry)

Environment: The C9 v.t. occurs on mesic to subxeric, Montane to Lower Subalpine sites (1400-1750 m) on nearly level slopes of southerly aspect in Banff. The soils are well drained Dystric and Eutric Brunisols, and some Orthic Gray Luvisols on fluvial, glaciofluvial, and glaciolacustrine landforms, primarily along the Bow and Spray River valleys.

Table 16 Stands representing the black spruce-lodgepole pine / willow / sedge (C8) v.t.

	CB 51 00	IC 50 78	IC 70 44	IC 70 96	JC 60 07	JC 60 08	JC 70 17	LC 90 24	LC 91 72	LC 91 78
TREE LAYER										
Larix laricina	--	--	--	--	--	--	--	--	--	05
Picea glauca	05	--	08	--	--	--	02	--	10	05
Picea mariana	--	07	--	10	12	10	23	50	10	20
Pinus contorta	15	.5	13	10	05	--	--	--	05	--
TALL SHRUB LAYER										
Picea glauca	05	--	01	--	--	--	.5	--	05	10
Picea mariana	--	--	--	05	03	40	.5	10	10	05
Pinus contorta	03	--	01	--	--	--	--	--	--	--
SHRUB LAYER										
Betula glandulosa	03	--	--	--	01	--	01	--	07	--
Betula pumila	--	--	15	08	--	04	--	--	--	--
Ledum groenlandicum	05	15	02	20	75	02	06	01	--	20
Picea glauca	01	--	.5	--	--	--	--	.5	--	03
Picea mariana	--	--	--	02	05	--	.5	--	--	--
Pinus contorta	--	--	01	.5	--	--	--	--	02	--
Potentilla fruticosa	07	.5	05	--	--	10	01	--	15	--
Rosa acicularis	--	.5	--	.5	.5	01	01	--	03	--
Salix glauca	03	--	.5	--	01	--	--	--	15	--
Salix myrtillifolia	--	05	01	08	02	25	11	--	--	15
HERB-DWARF SHRUB LAYER										
Anemone parviflora	.5	--	02	.5	--	01	.5	--	--	--
Arctostaphylos rubra	03	03	03	06	--	--	01	03	12	04
Arctostaphylos uva-ursi	--	--	--	--	--	02	--	--	08	01
Carex capillaris	--	--	02	01	--	03	--	10	--	--
Carex spp.	15	03	19	15	--	07	.5	--	13	15
Cornus canadensis	07	.5	--	--	.5	--	--	--	--	--
Elymus innovatus	03	--	--	--	--	04	10	--	.5	.5
Empetrum nigrum	03	03	03	--	--	--	--	--	--	--
Erigeron peregrinus	05	--	01	--	--	--	--	--	--	--
Galium boreale	--	.5	--	--	--	.5	.5	--	--	--
Linnaea borealis	--	.5	.5	.5	.5	--	.5	--	07	05
Pedicularis bracteosa	--	.5	02	.5	--	--	--	--	--	--
Petasites palmatus	.5	.5	--	.5	.5	--	01	--	05	--
Polygonum viviparum	--	--	.5	--	--	.5	--	--	--	--
Pyrola asarifolia	--	.5	--	.5	--	--	--	--	--	.5
Pyrola virens	--	--	.5	--	--	.5	--	--	--	--
Rubus acaulis	01	.5	--	--	--	--	.5	--	01	--
Vaccinium vitis-idaea	--	.5	.5	01	02	--	--	--	--	--
Zygadenus elegans	.5	.5	.5	.5	--	01	--	--	--	--
Equisetum arvense	--	01	--	.5	.5	--	01	02	03	03
Equisetum scirpoides	--	--	.5	.5	.5	01	03	04	--	04
Equisetum variegatum	--	.5	.5	.5	--	--	--	--	--	--
BRYOID LAYER										
Aulacomnium palustre	--	.5	30	20	--	--	05	05	10	40
Bryum pseudotriquetrum	--	--	--	--	--	--	.5	.5	--	.5
Campylium stellatum	--	.5	--	15	--	--	--	--	05	--
Cladonia spp.	.5	.5	--	.5	05	.5	.5	02	05	01
Dicranum spp.	--	02	05	--	.5	.5	.5	--	--	--
Distichium capillaceum	--	--	--	.5	--	--	--	--	--	.5
Ditrichum flexicaule	--	--	--	.5	--	--	--	--	03	.5
Drepanocladus spp.	--	--	--	05	--	--	--	.5	--	--
Eurhynchium pulchellum	--	--	--	.5	--	--	.5	--	--	--
Hylocomium splendens	03	25	10	10	45	--	70	50	20	.5
Peltigera aphthosa	.5	01	.5	.5	01	.5	.5	03	.5	--
Pleurozium schreberi	03	.5	03	10	01	--	.5	10	10	--
Ptilium crista-castrensis	--	--	--	--	--	--	.5	--	.5	05
Tomenthypnum nitens	--	30	--	15	--	--	.5	10	--	.5
EPIPHYTES										
Alectoria spp.	--	--	--	--	.5	--	--	--	.5	--
Cetraria pinastri	--	.5	--	--	--	--	--	.5	.5	--
Evernia mesomorpha	--	--	--	--	--	--	.5	--	--	--
Hypogymnia spp.	--	--	--	--	--	--	.5	.5	--	--
Letharia columbiana	--	--	--	--	--	--	.5	--	--	--
Letharia vulpina	--	--	--	--	--	--	.5	--	.5	--
Usnea spp.	--	--	--	--	.5	.5	.5	--	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: *Pinus contorta* (25-40%) dominates the closed tree layer (Table 17). The shrub layer has a total cover of 5 to 15% with *Shepherdia canadensis* (6%), *Rosa acicularis* (1%), and *Juniperus communis* (1%) dominant. The herb-dwarf shrub layer has moderate to dense cover (30-60%) and is dominated by *Vaccinium caespitosum* (10-25%). Other leading species include *Elymus innovatus* (5-10%), *Linnaea borealis* (5-10%), *Arctostaphylos uva-ursi* (6%), and *Calamagrostis rubescens* (2-10%). *Fragaria virginiana* and *Cornus canadensis* have low

cover but high frequency. The bryoid layer (25-60%) is dominated by *Pleurozium shcreberi* (10-25%) and *Peltigera aphthosa* (3-5%). Epiphytes are sparse with *Alectoria* spp. and *Letharia vulpina* most common.

Table 17 Stands representing the lodgepole pine / dwarf billberry (C9) v.t.

	AW	AW	AW	AW	IC	JD	KS	KB	KS	PA
	50	50	60	60	80	90	50	60	60	91
	53	57	17	76	81	91	97	96	58	38
TREE LAYER										
Picea glauca	--	--	03	01	.5	01	--	--	--	--
Pinus contorta	35	35	28	23	22	25	50	60	40	55
TALL SHRUB LAYER										
Picea glauca	02	03	.5	04	02	03	--	--	--	--
Pinus contorta	--	--	--	06	.5	02	.5	03	--	--
SHRUB LAYER										
Abies lasiocarpa	.5	--	.5	--	--	--	--	--	--	.5
Betula pumila	--	--	--	02	08	--	--	--	--	--
Juniperus communis	01	04	--	--	--	.5	06	01	.5	.5
Ledum groenlandicum	01	04	02	--	--	01	--	--	--	--
Picea glauca	02	01	03	01	01	--	.5	--	--	--
Pinus contorta	--	--	--	02	.5	03	.5	.5	.5	--
Potentilla fruticosa	--	01	--	02	--	.5	--	--	--	--
Rosa acicularis	02	02	01	--	--	.5	02	.5	.5	.5
Salix farrae	--	--	--	28	--	--	--	--	--	--
Salix glauca	01	.5	01	--	--	--	--	--	--	--
Shepherdia canadensis	07	08	07	01	06	02	.5	01	.5	35
HERB-DWARF SHRUB LAYER										
Achillea millefolium	.5	.5	--	03	.5	.5	--	--	.5	--
Antennaria nitida	--	--	--	--	--	.5	.5	.5	--	--
Arctostaphylos uva-ursi	01	08	01	--	04	25	--	12	12	--
Arnica cordifolia	01	01	08	01	--	.5	--	--	--	--
Aster ciliolatus	--	04	--	15	--	.5	--	--	--	--
Aster conspicuus	.5	--	01	--	--	.5	--	--	--	15
Calamagrostis rubescens	--	--	02	02	08	15	--	--	10	--
Carex concinna	--	--	--	--	--	01	02	.5	--	--
Cornus canadensis	09	05	02	03	--	.5	--	--	--	10
Elymus innovatus	03	04	04	08	10	10	06	05	03	10
Epilobium angustifolium	.5	.5	01	01	.5	.5	--	--	--	--
Fragaria virginiana	--	03	01	09	01	01	02	02	01	--
Linnaea borealis	04	21	15	04	--	05	04	06	15	10
Orygopsis asperifolia	.5	04	--	--	--	--	01	03	--	--
Solidago decumbens	--	--	--	--	.5	--	--	.5	.5	--
Solidago multiradiata	--	.5	--	--	--	--	.5	01	.5	--
Spiraea lucida	--	--	--	--	--	.5	--	--	--	10
Trisetum montanum	--	02	--	--	--	--	.5	--	--	--
Trisetum spicatum	--	--	--	04	--	--	--	.5	--	--
Vaccinium caespitosum	23	25	11	25	08	30	10	10	20	.5
BRYOID LAYER										
Aulacomium palustre	--	--	--	12	--	--	--	.5	--	--
Cetraria ericetorum	--	--	--	--	.5	--	02	10	10	--
Cladonia spp.	--	01	.5	.5	03	05	18	32	05	10
Dicranum scoparium	02	02	--	--	.5	--	--	--	--	--
Drepanocladus uncinatus	--	--	--	--	.5	--	--	--	.5	.5
Hylocomium splendens	--	--	10	.5	--	02	--	--	--	20
Peltigera aphthosa	30	02	01	--	.5	03	03	03	02	--
Peltigera canina	--	01	--	--	.5	--	03	--	--	--
Peltigera rufescens	--	--	--	--	--	--	--	10	05	05
Pleurozium schreberi	25	06	75	--	.5	03	--	--	.5	10
Polytrichum juniperinum	02	--	.5	03	--	.5	10	06	03	.5
Psoroma hypnorum	--	--	--	--	--	.5	--	--	.5	--
Stereocaulon alpinum	--	--	--	--	01	--	02	--	--	--
Stereocaulon tomentosum	--	--	--	--	--	--	--	03	--	.5
Barbilophozia hatcheri	--	01	.5	01	--	--	--	--	--	.5
EPIPHYTES										
Letharia vulpina	--	--	--	--	.5	--	.5	.5	.5	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Stands of C9 are intermediate to advanced successionally with *Picea glauca* or *P. glauca* x *P. engelmannii* common in the tree layer and as regeneration in lower layers. Most stands are 85 to 100 years old.

The C9 v.t. is distinguished from C35 by occurring in Banff, by the presence and usual dominance of *Shepherdia canadensis* in the shrub layer, by the dominance of *Vaccinium caespitosum* rather than *Empetrum nigrum* in the herb-dwarf shrub layer, and by a lower ground lichen cover, usually <25%. Table 12 compares C9 with four other *Pinus contorta* v.t.s. The C9 differs by having *Vaccinium caespitosum* dominant in the herb-dwarf shrub layer rather than *Aster conspicuus* (C6), *Vaccinium scoparium* (C18) or *Linnaea borealis* (C19). The C3 differs in having greater amounts of *Juniperus communis* and *Arctostaphylos uva-ursi*.

Other Studies: Similar Alberta forests were described by Ogilvie (1963) in Banff (*Pinus contorta/Calamagrostis rubescens-Vaccinium*) and by Mackenzie-Grieve (1970) for the Red Deer River area east of Banff (*Pinus-Picea/Vaccinium caespitosum-Vaccinium vitis-idaea/Hylocomium* and *Pinus-Picea /Shepherdia-Vaccinium/Hylocomium*). Pfister et al. (1977) described similar forests for Montana as seral stages of the *Picea/Vaccinium caespitosum* and *Abies lasiocarpa/Vaccinium caespitosum* types as well as the somewhat drier *Pinus contorta/Vaccinium caespitosum* type.

C10: *Pinus contorta/Alnus crispa/Hylocomium splendens*

(lodgepole pine/green alder/feathermoss)

Environment: The C10 forests occur on mesic Montane to Lower Subalpine (1000-1780 m J; 1700 m B), level to steeply sloping sites of predominantly northerly aspect, primarily in Jasper. Soils are well drained Eutric and Dystric Brunisols developed on morainal landforms.

Vegetation: *Pinus contorta* is the dominant tree (Plate 13) with 10 to 55% cover (Table 18). *Picea glauca* has up to 20% cover and occurs in about one-half of the sampled stands. The shrub layer has moderate to high cover (15-55%), the dominant being *Alnus crispa* (10-50%) with lesser amounts of *Rosa acicularis* (<5%), *Shepherdia canadensis* (<10%), and *Viburnum edule* (<5%). *Menziesia glabella* (<3%) occurs in one-half of the sampled stands. The herb-dwarf shrub layer has moderate cover (10-40%) with common representatives being *Linnaea borealis* (<10%), *Cornus canadensis* (<10%), *Elymus innovatus* (3-15%), *Pyrola secunda* (<3%), *Pyrola asarifolia* (<3%), *Arnica cordifolia* (<5%), and *Aster conspicuus* (<10%). The bryoid layer has generally high cover (15-70%) and is dominated by *Hylocomium splendens* (15-75%) with lesser amounts of *Pleurozium schreberi* (5-45%), *Ptilium crista-castrensis* (<10%), and *Peltigera aphthosa* (<5%). *Parmelia sulcata* and *Cetraria pinastri* are common epiphytes.

Successionally, C10 is intermediate with most stands 70 to 100 years old.

Table 18 Stands representing the lodgepole pine-white spruce / green alder / feathermoss (C10) v.t.

	1C 50 97	1C 91 18	1C 70 17	JC 70 09	JC 70 63	JD 91 33	JN 80 36	LC 90 14	SJ 70 12	SJ 70 68
TREE LAYER										
Picea engelmannii	--	--	--	--	05	.5	--	--	--	--
Picea glauca	03	--	.5	05	--	--	--	35	.5	--
Picea mariana	--	--	--	--	15	--	--	--	--	--
Pinus contorta	65	85	35	37	83	75	34	05	35	21
Populus tremuloides	--	--	--	--	05	--	--	--	--	--
Salix scouleriana	--	--	--	--	--	.5	--	--	--	04
TALL SHRUB LAYER										
Alnus crispa	25	--	--	10	50	10	17	--	07	15
Picea glauca	--	--	.5	02	--	--	--	05	10	--
Pinus contorta	--	--	--	--	--	--	02	--	--	--
Salix scouleriana	02	.5	.5	--	--	--	01	--	--	--
SHRUB LAYER										
Abies lasiocarpa	--	--	.5	--	.5	--	.5	--	01	.5
Alnus crispa	--	15	20	03	08	--	--	40	05	--
Juniperus communis	--	.5	.5	--	--	.5	--	--	--	--
Ledum groenlandicum	--	--	--	--	--	--	--	03	--	--
Lonicera involucrata	.5	--	--	--	--	.5	--	--	--	07
Menziesia glabella	.5	.5	.5	--	.5	02	01	02	--	--
Picea glauca	--	--	.5	--	--	--	01	--	03	--
Rhododendron albiflorum	.5	--	--	--	--	--	--	--	--	--
Ribes lacustre	--	--	--	--	--	.5	--	--	--	03
Rosa acicularis	03	.5	01	--	02	.5	05	--	.5	03
Salix bebbiana	--	--	--	--	--	--	03	--	--	--
Salix scouleriana	--	--	--	--	--	.5	--	--	--	.5
Salix vestita	--	--	--	.5	--	--	--	02	--	--
Salix spp.	--	--	--	01	--	--	--	10	.5	--
Shepherdia canadensis	02	05	05	15	--	15	20	10	15	.5
Spiraea lucida	--	--	.5	--	.5	--	02	--	--	--
Viburnum edule	.5	--	.5	01	.5	--	03	--	--	.5
HERB-DWARF SHRUB LAYER										
Arctostaphylos uva-ursi	--	.5	01	01	--	05	--	--	01	--
Arnica cordifolia	--	--	03	.5	.5	01	06	--	05	03
Aster ciliolatus	--	.5	02	--	--	--	--	.5	--	--
Aster conspicuus	15	07	05	01	--	01	03	--	--	--
Calypso bulbosa	--	--	--	--	--	--	.5	.5	01	--
Carex concinna	--	.5	--	.5	--	.5	.5	02	--	--
Castilleja miniata	--	--	.5	--	--	01	--	--	--	--
Clematis verticellaris	--	--	--	.5	--	--	.5	--	--	--
Cornus canadensis	01	01	15	02	01	20	07	03	.5	20
Elymus innovatus	15	04	05	02	.5	05	09	03	03	--
Epilobium angustifolium	--	01	.5	--	--	02	01	--	01	02
Galium triflorum	--	--	--	--	--	--	--	--	--	02
Linnaea borealis	05	12	10	04	.5	15	05	04	05	03
Mitella nuda	--	--	--	--	--	.5	.5	01	--	.5
Moneses uniflora	--	--	--	--	--	--	--	--	--	05
Osmorhiza depauperata	--	--	--	--	--	--	--	--	--	03
Pyrola asarifolia	--	--	02	.5	02	--	.5	--	01	.5
Pyrola secunda	.5	.5	--	.5	.5	15	01	04	01	.5
Pyrola virens	.5	.5	--	--	--	--	.5	--	--	--
Vaccinium scoparium	--	01	--	--	--	10	--	--	--	--
Equisetum scirpoides	--	--	--	--	--	.5	--	04	--	--
BRYOID LAYER										
Aulacomnium palustre	--	--	--	--	--	--	--	03	--	--
Cladonia chlorophaea	--	--	--	.5	.5	--	.5	--	--	--
Cladonia spp.	--	--	--	--	01	--	.5	03	02	01
Dicranum spp.	--	--	--	--	--	05	--	--	--	--
Drepanocladus uncinatus	--	--	--	01	--	--	--	01	.5	.5
Hylocomium splendens	50	40	35	10	85	03	10	50	85	07
Ptilium spinosum	--	--	--	--	--	--	--	--	--	.5
Peltigera aphthosa	02	01	01	--	.5	.5	.5	03	.5	--
Pleurozium schreberi	20	40	15	05	03	30	02	--	01	--
Polytrichum juniperinum	--	--	--	--	--	--	.5	--	.5	.5
Polytrichum spp.	--	--	--	--	--	10	--	--	--	--
Ptilium crista-castrensis	05	05	05	--	03	05	08	05	.5	01
Thuidium abietinum	--	--	--	20	--	--	.5	--	--	--
EPIPHYTES										
Bryoria glabra	--	--	--	--	--	.5	--	--	--	.5
Cetraria pinastri	--	--	--	--	--	--	.5	--	.5	.5
Hypogymnia austerodes	--	--	--	--	--	.5	--	.5	--	.5
Hypogymnia physodes	--	--	--	--	--	.5	--	.5	--	.5
Letharia vulpina	--	--	--	--	--	--	.5	.5	--	--
Parmelia sulcata	--	--	--	--	--	.5	--	.5	--	--
Parmeliopsis ambigua	--	--	--	--	--	.5	--	--	--	--
Parmeliopsis hyperopta	--	--	--	--	--	.5	--	--	--	--
Usnea scoredifera	--	--	--	--	--	--	--	--	--	.5
Usnea subfloridana	--	--	--	--	.5	--	--	--	--	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

The C10 v.t. is distinguished from other *Pinus contorta* v.t.s by the dominance of *Alnus crispa* in the shrub layer. Stands with low *Alnus* cover may be transitional to C11, if cover of other species is low, or to C6 or C19 if *Shepherdia canadensis* has cover greater than that of *Alnus*. At higher elevations, intergrades to C14 occur with *Menziesia glabella* replacing *Alnus*.

Other Studies: In Alberta, similar types have been described by Ogilvie (1963, *Pinus/Hylocomium-Alnus*), La Roi (1975) in Jasper (*Pinus contorta/Alnus crispa* types), Corns and La Roi (1976) in the northern foothills, Corns (1978) also in the northern foothills (*Pinus contorta/Alnus crispa/Cornus canadensis*), and by La Roi and Hnatiuk (1980) in Banff and Jasper (*Pinus contorta/Alnus crispa/Linnaea borealis*). Mackenzie-Grieve (1970) described several similar types in the Red Deer River valley east of Banff (*Picea-Pinus/Hylocomium, Pinus-Picea/Alnus/Hylocomium, Pinus-Picea/Hylocomium, Pinus/Alnus/Aster, and Pinus-Populus/Alnus/Elymus*). Jacques and Legge (1974) have described a *Picea Alnus crispa-Aster conspicuus* type from the Kananaskis area to which C10 appears seral. In northeastern British Columbia, Raup (1934) described "rich pine woods" which have much *Alnus crispa* in the understory. Pfister et al. (1977), in Montana, have described similar *Pinus contorta* dominated, seral stands of the *Abies lasiocarpa/Alnus sinuata* type.

C11: *Pinus contorta-Picea* spp./*Hylocomium splendens*

(lodgepole pine/feathermoss)

Environment: The C11 v.t. occurs on mesic Montane to Lower Subalpine (1250-1750 m), gently sloping (<25%) sites with northerly aspects. Soils are well drained Eutric Brunisols on glacial landforms, occasionally with eolian or fluvial veneers.

Vegetation: *Pinus contorta* is the dominant tree (Plate 14) with 5 to 65% cover (Table 19). Usually lesser amounts of at least one of *Picea glauca* (<30%), *Picea engelmannii* (<30%), or *Picea mariana* (<25%) are also present in the tree layer which may have cover of up to 75%. The shrub layer is generally sparse (<15%) but where *Abies lasiocarpa* regeneration is abundant, may be as high as 35%. The most commonly occurring shrubs are *Shepherdia canadensis* (<5%), *Ledum groenlandicum* (<10%), and *Rosa acicularis* (<2%). The herb-dwarf shrub layer has cover generally <35%, with the majority in low-growing species such as *Linnaea borealis* (<25%) and *Cornus canadensis* (<5%). Other species commonly present are *Pyrola secunda* (<3%), *Elymus innovatus* (<5%), and *Arnica cordifolia* (<10%). The bryoid layer is well developed (60-100%), dominated by *Hylocomium splendens* (30-60%) and *Pleurozium schreberi* (10-50%) with lesser amounts of *Ptilium crista-castrensis* (5-10%). *Peltigera aphthosa* (5-15%) is the predominant terrestrial lichen, with much lesser

amounts of *Cladonia* spp. (<5%). Epiphytes have moderate abundance, the dominants being *Cetraria pinastri*, *Hypogymnia physodes*, and *Letharia vulpina*.

Table 19 Stands representing the lodgepole pine / feathermoss (C11) v.t.

	AW 30 06	AN 60 49	IC 50 79	IC 80 12	IC 90 17	JC 60 06	JN 70 05	LC 90 96	PA 90 05	SJ 80 07
TREE LAYER										
Abies lasiocarpa	05	--	.5	--	--	--	--	--	.5	--
Picea engelmannii	--	--	--	--	18	12	--	--	--	01
Picea glauca	17	30	--	18	--	--	20	10	08	--
Picea mariana	--	--	03	--	--	23	15	--	--	--
Pinus contorta	40	45	40	22	15	40	05	15	67	12
TALL SHRUB LAYER										
Abies lasiocarpa	--	--	--	--	--	--	--	08	--	--
Picea engelmannii	--	--	--	--	02	02	--	--	--	02
Picea glauca	--	01	--	02	--	--	.5	02	.5	--
Picea mariana	--	--	--	--	.5	03	--	--	--	--
Pinus contorta	--	--	--	--	--	--	--	--	--	03
SHRUB LAYER										
Abies lasiocarpa	--	01	--	--	--	01	.5	07	.5	03
Juniperus communis	--	03	--	--	--	.5	--	--	--	04
Ledum groenlandicum	.5	--	.5	--	--	--	02	--	.5	.5
Menziesia glabella	.5	01	.5	--	--	01	.5	--	--	--
Picea engelmannii	--	--	--	--	.5	--	--	--	--	05
Picea glauca	--	.5	--	.5	--	--	--	--	.5	--
Pinus contorta	--	--	--	--	--	--	--	--	--	10
Rosa acicularis	.5	01	--	--	.5	--	.5	--	--	--
Salix vestita	--	--	--	--	--	--	--	--	--	15
Shepherdia canadensis	--	.5	--	--	--	--	--	--	.5	01
Viburnum edule	--	--	--	--	--	01	--	07	--	--
HERB-DWARF SHRUB LAYER										
Arctostaphylos rubra	--	--	--	--	.5	--	--	--	--	02
Arnica cordifolia	--	04	.5	--	--	.5	03	01	02	--
Aster conspicuus	--	03	--	--	--	--	--	--	--	--
Calypso bulbosa	--	--	--	--	--	--	.5	.5	--	.5
Cornus canadensis	02	08	.5	--	02	02	07	05	--	--
Elymus innovatus	--	01	.5	02	01	.5	.5	02	02	--
Epilobium angustifolium	--	--	--	.5	--	.5	--	--	03	.5	--
Linnaea borealis	05	28	--	02	01	.5	02	01	03	05
Mertensia paniculata	--	--	--	--	--	.5	--	07	01	.5	--
Pyrola secunda	01	.5	.5	--	01	01	.5	--	01	.5
Pyrola virens	--	.5	--	.5	--	.5	--	--	--	--
Rubus pedatus	--	--	--	--	--	--	--	07	--	--
Vaccinium vitis-idaea	04	--	.5	--	--	--	--	.5	--	.5	--
Zygadenus elegans	--	--	--	.5	--	--	--	--	.5	.5
Equisetum scirpoides	--	--	.5	--	.5	--	.5	--	--	--
Lycopodium annotinum	--	--	--	--	--	--	.5	--	02	--	--
BRYOID LAYER										
Cladonia cenotea	--	--	.5	--	--	--	--	.5	--	.5
Cladonia gonecha	--	--	.5	.5	--	--	--	02	--	.5
Cladonia spp.	--	.5	--	--	.5	--	--	--	--	--
Dicranum fuscescens	--	--	.5	--	--	--	--	03	.5	--
Dicranum scoparium	--	--	--	--	--	--	--	03	--	01
Drepanocladus uncinatus	--	01	--	--	--	--	--	01	--	.5
Hylocomium splendens	10	98	10	68	90	98	40	02	50	02
Peltigera aphthosa	04	09	01	--	01	.5	--	02	.5	03
Pleurozium schreberi	75	38	66	01	40	08	10	50	40	--
Pohlia nutans	--	--	.5	.5	--	--	--	.5	.5	.5
Polytrichum juniperinum	.5	--	.5	--	--	--	--	.5	--	--
Ptilium crista-castrensis	--	01	02	--	05	02	30	10	05	--
Barbilophozia hatcheri	--	--	.5	.5	--	--	--	01	--	--
EPIPHYTES										
Cetraria pinastri	--	--	.5	.5	--	--	--	--	--	.5
Letharia vulpina	--	--	.5	.5	--	--	--	--	.5	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Successionally C11 is intermediate to advanced and is probably seral to C13, with forests being 125 to 200 years old.

The C11 v.t. is distinguished from C13 by the dominance of *Pinus contorta*, from C20 by much less *Menziesia glabella* (<5%), from C19 by much less *Shepherdia canadensis* (<5%), and from C29 by low *Ledum groenlandicum* (<15%) and *Empetrum nigrum* (<2%) cover.

Other Studies: Similar types were described for Jasper and Banff by Laidlaw (1971, *Picea mariana-Hylocomium*) and for south central British Columbia by Illingworth and Arlidge (1960, *Pinus contorta/Cornus*-moss).

C12: ***Picea engelmannii-Pinus albicaulis/Menziesia glabella***

(Engelmann spruce-whitebark pine/false azalea)

Environment: The C12 v.t. occurs on mesic, mostly Lower Subalpine sites (1700-2100 m) on steep slopes of various aspects. The soils are well drained Eluviated Dystric Brunisols and Orthic Eutric Brunisols on morainal and colluvial landforms. C12 occurs mostly in the Main Ranges of Jasper and northern Banff, west of Highway 93 and between the North Saskatchewan and Miette Rivers.

Vegetation: The tree layer is closed (30-60%) and dominated by *Picea engelmannii* (10-20%), *Pinus albicaulis* (10-25%), and *Abies lasiocarpa* (5-20%) (Table 20). The moderately dense shrub layer (20-80%) is dominated by *Menziesia glabella* (20-75%). *Ledum groenlandicum* (5-10%) and *Abies lasiocarpa* (3-15%) are common. Often present, but with low cover, are *Rhododendron albiflorum*, *Pinus albicaulis*, and *Juniperus communis*. The herb-dwarf shrub layer, with a total cover of 10 to 70%, is dominated by dwarf shrubs: *Vaccinium scoparium* with very variable cover (5-60%), *Empetrum nigrum* (5-10%), *Vaccinium membranaceum* (1-5%), and *Vaccinium vitis-idaea* (<1%). The bryoid layer has a cover of 35 to 80% and is dominated by *Pleurozium schreberi* (20-35%). Other common species include *Dicranum scoparium* (5-10%), *Peltigera aphthosa* (1-2%), *Cladonia* spp. (1-5%), *Hylocomium splendens* (<1%), and *Barbilophozia* spp. (<1%). Epiphytes are moderately abundant with *Letharia vulpina*, *Parmeliopsis ambigua*, and *Parmeliopsis hyperopta* most common.

Stands of C12 are generally 200 to 300 years old and tree regeneration consists of *Picea engelmannii*, *Abies lasiocarpa*, and *Pinus albicaulis*. Thus, C12 is mature successionally.

The occurrence of *Pinus albicaulis* as a codominant tree in C12 differentiates it from C14.

Other Studies: Similar forests have been described in southwestern Alberta by Kuchar (1973) and Day (1967). Kuchar's (1978) whitebark pine forest in Yoho National Park, British Columbia includes stands similar to C12. Types lacking abundant *Menziesia glabella* and *Rhododendron albiflorum*, but otherwise similar, have been described from

Table 20 Stands representing the Engelmann spruce-whitebark pine / false azalea (C12) v.t.

	AW 50 25	AW 70 34	AW 70 59	1C 50 73	1C 60 68	1C 70 12	2C 60 83	2C 70 75	2D 50 30	2J 70 94
TREE LAYER										
Abies lasiocarpa	02	07	10	20	25	05	10	15	10	01
Larix lyallii	01	--	--	--	--	--	--	--	--	--
Picea engelmannii	08	10	09	10	20	15	22	08	25	--
Picea mariana	--	--	--	--	--	--	--	--	--	10
Pinus albicaulis	12	20	06	05	12	05	30	31	25	11
Pinus contorta	05	--	--	--	--	--	--	05	--	.5
TALL SHRUB LAYER										
Abies lasiocarpa	--	.5	04	--	10	05	05	05	03	10
Picea engelmannii	--	--	02	--	05	05	.5	--	--	--
Picea mariana	--	--	--	--	--	01	--	--	--	02
Pinus albicaulis	--	08	--	--	01	--	--	--	--	01
SHRUB LAYER										
Abies lasiocarpa	.5	15	03	--	15	03	13	03	25	--
Betula pumila	15	--	--	--	--	--	--	--	--	--
Juniperus communis	.5	01	--	--	--	--	01	.5	.5	--
Ledum groenlandicum	02	--	--	.5	05	10	--	--	.5	--
Menziesia glabella	55	--	15	75	45	25	--	12	03	20
Picea engelmannii	02	--	--	--	02	02	.5	--	--	--
Pinus albicaulis	01	--	01	--	02	.5	02	01	07	--
Rhododendron albiflorum	--	--	04	05	30	01	--	03	--	--
Salix vestita	05	--	--	--	--	--	--	--	--	--
Shepherdia canadensis	--	03	--	--	--	--	--	--	--	--
HERB-DWARF SHRUB LAYER										
Arctostaphylos rubra	--	02	--	--	.5	--	--	--	--	--
Arnica cordifolia	.5	--	--	--	--	--	--	.5	.5	--
Arnica latifolia	--	--	--	--	--	--	03	--	--	--
Cornus canadensis	.5	--	--	01	--	--	--	01	--	--
Dryas octopetala	--	12	--	--	--	--	--	--	--	--
Elymus innovatus	--	--	--	--	--	--	02	--	--	--
Empetrum nigrum	--	--	04	.5	10	12	--	--	01	30
Erigeron peregrinus	--	01	--	--	--	--	04	--	--	--
Erythronium grandiflorum	--	13	--	--	--	--	08	--	--	--
Fragaria virginiana	--	02	--	--	--	--	01	--	--	--
Ledum groenlandicum	--	--	09	--	--	--	--	--	--	--
Pedicularis bracteosa	.5	03	--	--	--	--	02	--	--	--
Phyllodoce empetriformis	02	--	--	.5	--	--	--	01	--	--
Phyllodoce glanduliflora	--	--	--	--	05	--	--	01	--	--
Vaccinium membranaceum	--	--	01	01	20	03	--	--	05	--
Vaccinium scoparium	45	02	.5	01	--	--	55	08	60	--
Vaccinium vitis-idaea	--	--	02	.5	.5	03	--	--	--	04
Zygadenus elegans	.5	.5	--	--	--	--	.5	--	--	--
BRYOID LAYER										
Cetraria ericetorum	--	--	--	--	--	05	--	--	--	.5
Cladonia mitis	--	--	--	.5	01	--	--	--	--	07
Cladonia cornuta	--	--	--	--	--	01	--	.5	--	.5
Cladonia ecmocyna	--	--	--	.5	--	01	--	.5	--	.5
Cladonia phyllophora	--	--	--	.5	--	01	--	--	--	.5
Cladonia spp.	25	01	--	--	--	--	--	--	01	--
Dicranum acutifolium	--	--	--	--	--	02	--	--	--	.5
Dicranum fuscescens	--	--	--	.5	--	--	--	--	45	--
Dicranum scoparium	.5	--	--	.5	--	--	--	60	.5	--
Dicranum spp.	--	--	01	--	10	--	05	--	--	--
Drepanocladus revolvens	--	--	--	--	--	--	20	--	--	--
Hylocomium splendens	--	--	10	40	35	01	--	--	--	01
Hypnum arcticum	--	--	--	--	--	--	--	--	--	05
Peltigera aphthosa	02	--	08	01	01	02	01	.5	01	02
Pleurozium schreberi	--	--	06	35	30	20	--	15	.5	15
Pohlia nutans	--	--	--	.5	--	--	--	--	.5	.5
Ptilium crista-castrensis	--	--	10	03	--	--	05	--	--	--
Stereocaulon alpinum	--	--	--	--	--	--	--	--	--	02
Tortula ruralis	--	--	06	--	--	--	--	--	--	--
Dicranum brevifolium	--	--	--	--	--	01	--	30	--	--
Barbilophozia hatcheri	--	--	--	--	--	.5	30	--	01	--
Barbilophozia lycopodioides	.5	--	--	.5	--	--	--	.5	01	--
Barbilophozia spp.	--	--	--	--	20	--	--	--	--	--
EPIPHYTES										
Bryoria glabra	--	--	--	--	--	--	--	.5	--	02
Letharia vulpina	--	--	--	--	--	--	--	.5	.5	.5
Parmeliopsis ambigua	--	--	--	.5	--	.5	--	.5	--	.5
Parmeliopsis hyperopta	--	--	--	.5	--	--	--	.5	--	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Montana by Weaver and Dale (1974, *Pinus albicaulis-Vaccinium scoparium*) and Pfister et al. (1977, *Abies lasiocarpa-Pinus albicaulis/Vaccinium scoparium)* and central Wyoming by Reed (1976, *Pinus albicaulis-Vaccinium scoparium).*

C13: *Picea engelmannii-Abies lasiocarpa/Hylocomium splendens*

(Engelmann spruce-subalpine fir/feathermoss)

Environment: The C13 v.t. occurs on mesic to subhygric, predominantly Lower Subalpine (1250-2150 m J, 1390-2210 m B), level to steeply sloping sites on various aspects. Soils are well to moderately well drained Eutric and Dystric Brunisols and Regosols developed on glacial, colluvial, glaciofluvial and fluvial landforms.

Vegetation: *Picea engelmannii* is the dominant canopy tree (Plate 15) with 20 to 55% cover while *Abies lasiocarpa* usually has <15% cover (Table 21). Total tree cover is 25 to 60%. The shrub layer has low to moderate cover (10-40%) comprised primarily of regeneration of *Abies lasiocarpa* (5-15%) and *Picea engelmannii* (<10%). The herb-dwarf shrub layer has low cover (10-20%), characterized by *Pyrola secunda* (<3%), *Elymus innovatus* (<5%), *Linnaea borealis* (<10%), *Arnica cordifolia* (<5%), and *Equisetum scirpoides* (<5%). The bryoid layer has high cover (75-100%), dominated by *Hylocomium splendens* (30-75%) and *Pleurozium schreberi* (10-60%) with lesser amounts of *Ptilium crista-castrensis* (<15%), *Barbilophozia lycopodioides* (<5%), *Peltigera aphthosa* (<10%), and *Cladonia ecmocyna* (<1%). *Letharia vulpina* and *Parmeliopsis ambigua* are common epiphytes.

Succcessionally, C13 is mature with most stands 200 to 350 years old.

The C13 v.t. is distinguished from other similar v.t.s more by the absence rather than by presence or dominance of certain species. Some stands at the lower elevational limits of C13, where *Pseudotsuga menziesii* is present, are transitional to C5, or if *Pinus contorta* contributes significantly to the tree canopy, these stands are transitional to C11. Stands with *Menziesia glabella* cover approaching 20% or *Ledum groenlandicum* cover approaching 10% may be transitional to C14 or C30 respectively. High elevation stands with *Salix vestita* cover >5% or *Vaccinium scoparium* cover >15%, may be transitional to C24 or C15 respectively. The C13 v.t. is differentiated from C31 by having total cover of *Elymus innovatus* plus *Arnica cordifolia* plus *Linnaea borealis* <10% and *Elymus innovatus* cover <5%.

Other Studies: Similar forests are common from southern Yukon and Northwest Territories through northern and western Alberta and British Columbia. Orloci and Stanek (1979) described similar types *(Picea-HylocomiumPeltigera* and *Picea-Cornus-Hylocomium*) from southern Yukon; Jeffrey (1964) in the Mackenzie Mountains of southern Northwest Territories described similar mixed coniferous forest at high elevations. Farther south in west central Alberta foothills, similar vegetation was de-

Table 21 Stands representing the Engelmann spruce-subalpine fir / feathermoss (C13) v.t.

	AW	BR	IC	JC	JB	JS	JW	BE	BL	BJ
	81	84	78	78	81	90	78	81	80	81
	38	67	46	48	16	72	64	11	94	29
TREE LAYER										
Abies lasiocarpa	--	05	33	05	20	20	27	--	01	25
Picea engelmannii	--	25	17	35	25	10	03	09	05	35
Picea glauca	30	--	--	--	--	--	--	--	--	--
Pinus contorta	01	--	--	--	--	--	--	10	--	.5
TALL SHRUB LAYER										
Abies lasiocarpa	--	06	01	09	20	06	01	--	.5	02
Picea engelmannii	--	02	--	04	05	01	--	05	15	01
Picea glauca	05	--	--	--	--	--	--	--	--	--
Populus tremuloides	01	--	--	--	--	--	--	--	--	--
SHRUB LAYER										
Abies lasiocarpa	--	35	02	17	30	03	15	--	.5	02
Picea engelmannii	--	--	.5	02	--	.5	--	--	30	02
Rosa acicularis	03	--	--	--	--	--	--	.5	--	--
Shepherdia canadensis	05	--	--	--	--	--	--	.5	--	--
HERB-DWARF SHRUB LAYER										
Abies lasiocarpa	--	03	--	--	--	.5	--	--	--	12
Cornus canadensis	--	--	--	--	--	--	--	10	--	--
Elymus innovatus	02	--	--	--	--	--	--	.5	01	--
Linnaea borealis	--	--	--	--	--	--	--	10	--	--
Pedicularis bracteosa	--	--	--	--	--	.5	--	--	05	--
Pyrola secunda	.5	--	.5	01	--	01	--	.5	.5	.5
Rubus pedatus	--	--	06	--	--	--	--	--	--	--
Vaccinium membranaceum	--	--	07	--	--	--	--	--	--	.5
Vaccinium myrtillus	--	02	--	--	--	--	03	--	--	--
Vaccinium scoparium	--	06	06	--	--	--	07	--	--	01
Equisetum scirpoides	--	--	--	06	.5	--	--	--	02	--
Lycopodium annotinum	--	--	03	--	--	01	--	--	--	.5
BRYOID LAYER										
Cladonia ecmocyna	--	--	--	--	.5	--	.5	.5	--	--	.5
Cladonia gonecha	--	06	--	--	--	--	--	.5	--	.5	.5
Cladonia spp.	.5	06	01	03	01	01	01	--	02	02
Dicranum fuscescens	--	05	--	--	--	25	--	--	--	--
Dicranum scoparium	--	--	--	--	--	--	--	06	03	15	--
Dicranum spp.	.5	--	03	--	20	--	--	--	--	--
Drepanocladus uncinatus	04	--	--	.5	40	--	--	.5	.5	--
Hylocomium splendens	65	45	30	45	20	35	30	80	50	65
Peltigera aphthosa	02	03	01	02	05	01	--	10	10	01
Peltigera canina	--	--	--	--	--	.5	--	.5	.5	.5
Pleurozium schreberi	05	20	60	20	--	--	60	--	--	25
Pohlia nutans	--	--	--	.5	--	10	.5	--	--	--
Ptilium crista-castrensis	.5	01	05	10	--	.5	--	05	--	--
Timmia austriaca	--	--	--	.5	05	--	--	.5	--	--
Barbilophozia lycopodioides	--	10	--	07	05	.5	.5	--	.5	.5
Blepharostoma trichophyllum	--	--	--	--	--	10	--	--	--	--
EPIPHYTES										
Bryoria fremontii	--	--	--	.5	--	.5	--	--	--	.5
Hypogymnia physodes	--	--	--	--	.5	--	--	.5	--	.5
Usnea spp.	--	.5	--	--	.5	--	.5	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

scribed by Corns (1978, *Picea glauca/Hylocomium splendens*) and Lesko and Lindsay (1973, white spruce-feathermoss-alpine fir). In the Kananaskis area of Alberta, Kirby and Ogilvie (1969) described a similar type (*Picea-Abies/Hylomium-Cornus*) as did Jacques and Legge (1974, spruce-fir/*Cornus canadensis-Hylocomium splendens*) and Kondla (1978, spruce-fir/feathermoss and spruce/feathermoss types) also in the Kananaskis area. In Banff, forests described by Ogilvie (1976, *Picea-Abies/Hylocomium-Cornus*) are analogous and in Jasper, Hettinger's (1975) types (*Picea glauca/Linnaea borealis-Hylocomium splendens*, *Picea glauca/Carex vaginata-Linnaea borealis*, *Picea engelmannii-Abies lasiocarpa/Arnica cordifolia*, and *Picea engelmannii-Abies lasiocarpa/Arnica diversifolia*) are similar. In southern Alberta, climax coniferous vegetation described by Cormack (1953) is comparable, as is that described by Kuchar (1973) for Waterton Lakes National Park (spruce/fir/bunchberry). Similar types are also described from British Columbia by Kuchar (1978) in Yoho National Park (spruce-fir/five-leaved bramble, spruce-fir/bryophytes-lichens) and by Illingworth and Arlidge 1960) in south-central British Columbia (*picea glauca-Abies lasiocarpa/Cornus-moss).*

C14: ***Picea engelmannii-Abies lasiocarpa/Menziesia glabella/Vaccinium scoparium***

(Engelmann spruce-subalpine fir/false azalea)

Environment: The C14 forests occur on mesic to subhygric, Lower Subalpine (1360-1860 m J, 1500-2040 m B), level to steeply sloping sites of predominantly northerly aspect in western Jasper and Banff. The soils are well to moderately well drained Eutric and Dystric Brunisols, and Orthic Humo-Ferric Podzols developed primarily on glacial and colluvial landforms.

Vegetation: *Picea engelmannii* (15-75%) dominates the tree layer (Table 22, Plate 16). *Abies lasiocarpa* (5-15%) is usually present. Shrub cover is dense, (40-90%) dominated by *Menziesia glabella* (20-70%). *Ledum groenlandicum* (<10%) is present in about one-half of the sampled stands and *Rhododendron albiflorum* (<20%) may be abundant in high elevation stands. The herb-dwarf shrub layer is moderately well developed with 15 to 50% cover and is dominated by *Vaccinium scoparium* (5-40%) in most of Banff and Jasper but is replaced by *Vaccinium membranaceum* (5-15%) in northern Jasper. *Vaccinium myrtillus* (5-25%) occurs in about one-third of the stands. Other common species are *Cornus canadensis* (<5%), *Arnica cordifolia* (<10%), *Pyrola secunda* (<1%), *Lycopodium annotinum* (<5%), and *Linnaea borealis* (3-15%). The bryoid layer has high cover (70-90%) and is dominated by *Pleurozium schreberi* (25-60%), *Hylocomium splendens* (25-60%), and *Ptilium crista-castrensis* (5-15%). *Dicranum* spp. (<10%), *Barbilophozia lycopodioides* (5-20%), and *Barbilophozia hatcheri* are also important. Lichen cover is low (<10%), dominated by *Peltigera aphthosa* (<10%) and *Cladonia* spp., especially *Cladonia ecmocyna* (<2%).

Stands of C14 are successionally mature and are 100 to 300 years old.

The C14 v.t. is distinguished from C20, from which it succeeds, by having *Picea engelmannii* rather than *Pinus contorta*. The C14 is distinguished from C21 and other *Picea-Abies* types by abundant *Menziesia glabella*. Intergrades to C20 and C21 occur and stands with sparse *Menziesia* cover may be transitional to C13.

Table 22 Stands representing the Engelmann spruce-subalpine fir / false azalea (C14) v.t.

	AM	AM	GM	IC	JC	JD	JD	JE	KE	PA
	80	80	65	70	61	65	90	91	80	70
	16	42	45	91	04	89	24	44	34	69
TREE LAYER										
Abies lasiocarpa	35	05	13	00	12	05	30	30	40	35
Picea engelmannii	11	35	33	13	21	35	05	15	25	30
Pinus contorta	--	--	--	--	07	--	--	--	--	--
TALL SHRUB LAYER										
Abies lasiocarpa	--	05	10	03	10	--	03	02	15	05
Picea engelmannii	--	--	05	.5	.5	03	01	01	--	--
DWARF SHRUB LAYER										
Abies lasiocarpa	--	07	10	05	--	05	01	01	10	01
Juniperus communis	.5	--	--	--	02	--	--	--	--	--
Ledum groenlandicum	17	01	--	06	--	.5	05	03	.5	--
Lonicera involucrata	--	01	--	--	02	--	--	--	--	--
Menziesia glabella	65	65	60	30	65	60	35	61	70	30
Picea engelmannii	--	--	02	.5	--	--	--	.5	--	--
Rhododendron albiflorum	--	03	--	--	05	.5	01	--	05	10
Ribes lacustre	--	--	03	--	--	--	--	--	--	--
HERB-DWARF SHRUB LAYER										
Abies lasiocarpa	--	--	03	--	--	--	--	.5	.5	--	.5
Arnica cordifolia	01	10	04	--	.5	01	--	--	--	05	--
Carex concinnoides	01	01	--	--	--	.5	--	--	--	--	--
Cornus canadensis	.5	03	03	01	01	.5	.5	01	03	--	
Elymus innovatus	01	--	--	--	--	.5	--	--	--	--	
Empetrum nigrum	.5	--	--	05	.5	02	--	--	.5	--	
Fragaria virginiana	01	01	--	--	--	--	--	--	--	--	
Ledum groenlandicum	--	--	--	--	--	01	--	--	--	--	
Linnaea borealis	06	03	--	--	01	01	--	--	01	--	
Phyllodoce empetriformis	--	02	--	--	--	--	--	--	--	--	
Pyrola secunda	--	.5	01	--	--	.5	.5	--	.5	--	
Senecio indecorus	.5	.5	--	--	--	--	--	--	--	--	
Stenanthium occidentale	01	.5	--	--	--	.5	--	--	--	--	
Vaccinium membranaceum	--	--	03	02	--	--	05	15	--	01	
Vaccinium myrtillus	02	01	07	--	--	10	--	--	--	--	
Vaccinium ovalifolium	--	--	--	--	--	--	--	--	--	05	
Vaccinium scoparium	35	10	05	15	03	15	--	--	10	05	
Viola orbiculata	--	--	--	--	--	--	01	--	--	--	
Lycopodium annotinum	--	--	02	--	--	--	--	--	--	--	
	--	--	04	--	--	--	--	--	--	--	
BRYOID LAYER										
Cladonia coniocraea	--	--	01	.5	--	--	--	--	--	--	
Cladonia spp.	--	01	--	01	--	.5	.5	.5	.5	.5	
Dicranum fuscescens	--	--	10	20	--	--	--	--	02	--	
Dicranum muehlenbeckii	--	--	--	--	--	.5	01	--	--	--	
Dicranum scoparium	--	03	--	--	--	--	--	.5	.5	10	
Drepanocladus uncinatus	--	--	05	--	--	--	--	--	.5	--	
Hylocomium splendens	--	35	10	15	30	50	50	45	35	25	
Lophozia sp.	--	--	--	03	--	--	--	--	--	--	
Peltigera aphthosa	11	02	02	.5	02	02	02	01	10	.5	
Peltigera canina	--	--	02	--	--	.5	.5	--	--	--	
Pleurozium schreberi	30	50	10	45	40	35	05	25	20	30	
Ptilium crista-castrensis	05	01	--	.5	05	10	35	10	05	.5	
Timmia austriaca	--	--	30	--	--	--	--	--	--	--	
Tortula norvegica	--	--	05	--	--	--	--	--	--	--	
Barbilophozia hatcheri	--	--	--	--	04	--	--	--	25	--	
Barbilophozia lycopodioides	--	--	05	--	--	.5	.5	--	--	05	
Barbilophozia spp.	--	05	--	--	--	--	--	--	--	--	
EPIPHYTES										
Alectoria spp.	.5	.5	.5	--	.5	.5	--	.5	.5	--	
Letharia vulpina	--	.5	.5	.5	--	.5	.5	.5	--	--	
Usnea spp.	--	.5	.5	--	.5	.5	--	--	.5	--	

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Other Studies: In Banff, Trottier and Scotter (1973) described similar types (*Picea-Abies/Menziesia glabella-Vaccinium scoparium*, *Picea-Abies /Menziesia glabella*/moss). In Jasper, similar types have been described by Hettinger (1975, *Picea engelmannii-Abies lasiocarpa/Menziesia glabella-Vaccinium membranaceum*), La Roi (1975, *Picea engelmannii/Abies lasiocarpa/Menziesia glabella/Valeriana sitchensis/Vaccinium scoparium/Pleurozium schreberi*), and Beil (1966). In other parts of Alberta, similar types have been described by Ogilvie (1976, Kirby and Ogilvie 1969, *Picea-Abies/Menziesia ferruginea -Lycopodium annotinum*), Kondla (1978) in Kananaskis Provincial Park (spruce-fir/false azalea-feathermoss), Kuchar (1973) in Waterton Lakes National Park (fir/spruce/menziesia), Jacques and Legge (1974) in the Kananaskis area (*Picea-Abies/Menziesia ferruginea-Tiarella unifoliata*, *Picea-Abies/Menziesia-Lycopodium annotinum*), and by Cormack (1953). In the northern foothills of Alberta, Corns (1978) has described a *Picea engelmannii-Abies lasiocarpa/Menziesia glabella* type similar to C14 stands in northern Jasper where *Vaccinium membranaceum* replaces *Vaccinium scoparium*. Shepherd (1959) has described a *Picea engelmannii-Abies/Peltigera* association in Banff, Kootenay and Yoho National Parks in Alberta and British Columbia. McLean (1970) described an *Abies lasiocarpa-Menziesia ferruginea* type from British Columbia. In Montana, Pfister et al. (1977) have described an *Abies lasiocarpa/Menziesia ferruginea* type. Daubenmire and Daubenmire (1968), in northern Idaho and eastern Washington, have a similar *Abies lasiocarpa-Menziesia ferruginea* type.

C15: *Picea engelmannii-Abies lasiocarpa/Vaccinium scoparium*

(Engelmann spruce-subalpine fir/grouseberry)

Environment: The C15 forests occur on mesic Upper Subalpine (1800-2140 m J; 1870-2240 m B), level to steeply sloping sites of predominantly southerly aspect in Banff and Jasper. Soils are well to moderately well drained Eutric and Dystric Brunisols, and Orthic Humo-Ferric Podzols developed primarily on morainal landforms.

Vegetation: *Picea engelmannii* (10-40%) is the dominant tree (Plate 17) while *Abies lasiocarpa* (<25%) is often codominant (Table 23). *Pinus contorta* and *Larix lyallii* occur occasionally. Tree cover is 20 to 60%. The shrub layer has variable cover (5-50%) and is dominated by *Abies lasiocarpa* (5-30%) and *Picea engelmannii* (<5%) regeneration. *Juniperus communis* (<5%) occurs in about one-half the sampled stands. The herb-dwarf shrub layer has moderate to high cover (25-85%) and is dominated by *Vaccinium scoparium* (15-60%) with lesser amounts of *Arnica cordifolia* (<10%), *Pedicularis bracteosa* (<10%), *Epilobium angustifolium* (<5%), and *Erigeron peregrinus* (<5%). *Phyllodoce* spp. and *Cassiope* spp., which are abundant in other Upper Subalpine v.t.s, are absent from many C15 stands or, where present, cover is usually <10%. Bryoid cover is generally high (40-85%) but is nearly absent in some stands. Moss cover varies from 5 to 85% dominated by *Pleurozium schreberi* (10-30%), *Barbilophozia lycopodioides* (5-20%), and *Barbilophozia hatcheri* (5-20%), with *Dicranum scoparium* (5-25%) often present. *Peltigera aphthosa* (<10%) is the dominant lichen and *Letharia vulpina* and *Alectoria* spp. are common epiphytes.

Table 23 Stands representing the Engelmann spruce-subalpinefir / grouseberry (C15) v.t.

	AN	AM	CE	GN	JC	JE	JN	KB	PA	SJ
	90	91	90	60	82	81	70	91	71	91
	47	44	72	63	36	27	61	20	90	85
TREE LAYER										
Abies lasiocarpa	09	04	--	03	--	04	11	15	11	04
Larix lyallii	--	--	--	04	--	--	--	--	--	--
Picea engelmannii	02	20	15	13	25	16	13	55	25	23
Pinus contorta	05	--	05	--	--	--	--	--	.5	04
TALL SHRUB LAYER										
Abies lasiocarpa	--	--	--	06	01	18	02	10	05	01
Larix lyallii	--	--	--	03	--	--	--	--	--	--
Picea engelmannii	--	.5	.5	01	06	02	--	15	05	02
SHRUB LAYER										
Abies lasiocarpa	03	03	05	15	02	06	15	12	05	06
Juniperus communis	06	--	05	07	--	--	--	--	--	02
Larix lyallii	--	--	--	03	--	--	--	--	--	--
Picea engelmannii	--	.5	--	--	01	01	--	--	05	15
Salix glauca	01	.5	--	--	--	.5	--	--	--	02
Salix vestita	--	--	--	--	--	03	--	--	--	--
HERB-DWARF SHRUB LAYER										
Antennaria racemosa	04	.5	--	--	--	--	--	--	--	--
Arctostaphylos rubra	03	--	--	--	--	--	--	--	--	--
Arenaria capillaris	03	--	--	--	--	--	--	--	--	--
Arnica cordifolia	01	.5	25	03	--	--	01	03	--	01
Cornus canadensis	--	--	--	03	--	--	--	--	--	--
Elymus innovatus	--	.5	07	--	01	--	--	--	--	.5
Empetrum nigrum	--	--	--	--	20	--	--	--	--	03
Epilobium angustifolium	.5	.5	.5	--	--	--	--	--	--	.5
Equisetum scirpoides	--	--	--	--	--	--	02	--	--	--
Erythronium grandiflorum	--	--	01	--	--	--	--	01	--	--
Fragaria virginiana	02	.5	.5	--	--	--	--	--	--	--
Hedysarum sulphurescens	02	--	01	--	--	--	--	--	--	--
Juniperus communis	--	--	--	--	02	--	--	--	15	--
Linnaea borealis	--	11	--	--	--	--	--	--	--	--
Pedicularis contorta	01	--	--	--	--	--	--	--	--	--
Penstemon spp.	01	--	--	--	--	--	--	--	--	--
Phyllodoce empetriformis	--	--	--	--	--	--	02	05	--	--
Phyllodoce glandulifiora	--	--	--	05	--	12	--	--	--	--
Phyllodoce spp.	.5	--	--	--	15	--	--	--	--	--
Pyrola secunda	--	.5	--	--	--	--	03	--	--	--
Saxifraga bronchialis	02	--	--	--	--	--	--	--	--	--
Senecio lugens	.5	.5	--	--	.5	--	--	--	.5	--
Vaccinium myrtillus	--	--	--	05	--	--	--	--	--	--
Vaccinium scoparium	14	15	30	20	40	10	25	50	40	13
Valeriana sitchensis	01	.5	--	--	--	--	--	--	--	--
Viola orbiculata	--	--	.5	--	--	--	--	02	--	--
EPIGEOID LAYER										
Barbilophozia hatcheri	--	--	--	--	--	.5	--	30	--	.5
Barbilophozia lycopodioides	--	--	--	06	60	.5	02	30	--	.5
Cladonia ecmocyna	--	--	--	08	.5	01	01	02	--	.5
Cladonia spp.	--	.5	--	--	01	.5	01	--	01	.5
Dicranum brevifolium	--	--	--	--	--	--	02	--	.5	01
Dicranum muehlenbeckii	--	--	--	25	20	04	--	.5	--	--
Dicranum scoparium	--	--	--	25	--	04	--	15	--	--
Dicranum undulatum	--	--	--	--	--	--	--	15	--	--
Dicranum spp.	--	05	--	--	--	--	--	--	--	--
Drepanocladus uncinatus	--	06	--	--	--	.5	--	.5	--	--
Hylocomium splendens	--	20	--	--	05	17	45	--	--	--
Peltigera aphthosa	--	12	--	03	--	03	.5	03	02	01
Peltigera canina	--	--	--	--	.5	.5	.5	--	--	.5
Pleurozium schreberi	--	50	--	05	10	--	45	.5	--	01
EPIPHYTES										
Letharia vulpina	--	--	--	.5	.5	.5	--	--	--	.5
Alectoria spp.	--	--	--	.5	--	--	.5	.5	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Successionally, C15 is mature with most stands 200 to 350 years old.

The C15 v.t. is distinguished from C34 and O10 by having low heath cover (<10%) and by high *Vaccinium scoparium* cover (15-60%). The C21 v.t. differs by having generally higher *Rhododendron albiflorum* and *Menziesia glabella* cover than C15 and by the dominance of *Vaccinium membranaceum* over *Vaccinium scoparium*. Stands transitional to C23 may occur where *Larix lyallii* has over one-half of the canopy cover or to C14 where *Menziesia glabella* cover approaches 20%.

Other Studies: Similar types occur from northern Jasper to Utah along the Rocky Mountains and westward to British Columbia and eastern Washington. In Alberta, similar types were described by La Roi (1975) for Jasper (*Abies lasiocarpa/Vaccinium scoparium/Barbilophosia lycopodioides*), for Banff by Ogilvie (1976, *Picea-Abies/Vaccinium scoparium/Phyllodoce* ssp.), Trottier and Scotter (1973, *Picea-Abies/Phyllodoce* ssp., *Picea-Abies/Vaccinium scoparium Picea-Abies/Vaccinium scoparium-Phyllodoce* ssp.-*Empetrum nigrum*), and for the Kananaskis area by Kirby and Ogilvie (1969, *Picea-Abies/Vaccinium scoparium*), Jacques and Legge (1974, spruce-fir/grouseberry), and Kondla (1978, spruce-fir/grouseberry). In British Columbia, similar types were described by McLean (1970) for the south-central part of the province (*Abies lasiocarpa-Vaccinium scoparium*), Kuchar (1978) for Yoho National Park (spruce-fir/grouseberry) and Kujala (1945) in central British Columbia (*Picea engelmannii-Abies lasiocarpa/Vaccinium scoparium*). Farther south, similar types have been described by Pfister et al. (1977) for Montana (*Abies lasiocarpa/Vaccinium scoparium*), by Bamberg and Major (1968) for the Flint Creek Mountains of west central Montana, by Patten (1963) for the Madison Range, southwestern Montana, and Daubenmire and Daubenmire (1968) for northern Idaho and eastern Washington (*Abies lasiocarpa-Vaccinium scoparium*). Similar types also occur in Wyoming, described by Reed (1976) for the Wind River Mountains (*Picea engelmannii-Vaccinium scoparium*), Despain (1973) for the Bighorn Mountains(*Picea engelmannii-Abies lasiocarpa*), Hoffman and Alexander (1976) for the Bighorn Mountains (*Picea engelmannii/Vaccinium scoparium, Abies lasiocarpa/Vaccinium scoparium*), Wirsing and Alexander (1975) for southeast Wyoming (*Abies lasiocarpa/Vaccinium scoparium*), and Oosting and Reed (1952) in the Medicine Bow Mountains. In Utah, Pfister (1972) has described an *Abies lasiocarpa/Vaccinium scoparium* type.

C16: *Populus tremuloides/Elymus innovatus-Lathyrus ochroleucus*

(aspen/hairy wild rye-peavine)

Environment: The C16 v.t. occurs on mesic, Montane to Lower Subalpine sites (1050-1550 m) on gentle slopes of southerly aspect in Banff and Jasper. The soils are well drained Orthic Eutric Brunisols and Regosols on fluvial landforms. A few stands in Jasper have Eutric Brunisols and Brunisolic Gray Luvisols developed on morainal landforms.

Vegetation: *Populus tremuloides* (20-60%) is dominant in the tree layer (Table 24, Plate 18). The shrub layer is moderately dense

(10-25%) with *Rosa acicularis* (5-10%), *Shepherdia canadensis* (5-15%), and *Juniperus communis* (<1%). The herb-dwarf shrub layer is dense (40-85%) and species rich with *Elymus innovatus* (15-40%) usually dominant. In Banff, *Calamagrostis rubescens* may be dominant to codominant. Other important species include: *Lathyrus ochroleucus* (1-3%), *Aster conspicuus* (<1%), and *Fragaria virginiana* (1-5%). Other species with low cover but high frequency are *Galium boreale*, *Vicia americana*, and *Achillea millefolium*. Lichens and bryophytes are scarce.

Table 24 Stands representing the aspen / hairy wild rye-peavine (C16) v.t.

	AW	IC	IC	IC	KS	KS	KS	PA	SJ	SJ
	60	50	51	51	50	50	51	70	70	90
	32	66	05	34	43	80	67	15	08	17
TREE LAYER										
Picea glauca	03	01	--	02	--	--	05	--	07	--
Populus tremuloides	31	35	50	65	60	65	45	25	30	30
TALL SHRUB LAYER										
Picea glauca	01	--	.5	--	02	--	08	.5	10	--
Populus tremuloides	--	--	--	--	--	--	--	01	06	01
SHRUB LAYER										
Cornus stolonifera	--	--	--	10	--	--	--	--	02	--
Elaeagnus commutata	.5	--	--	--	--	--	15	--	--	--
Juniperus communis	--	--	--	--	--	.5	.5	.5	--	--
Lonicera dioica	.5	--	--	01	--	--	--	--	02	--
Picea glauca	05	--	--	--	08	08	--	--	--	03
Populus tremuloides	02	--	--	--	.5	.5	.5	--	--	--
Ribes oxyacanthoides	--	--	--	.5	--	.5	.5	--	--	--
Rosa acicularis	04	01	02	05	20	02	10	.5	02	08
Shepherdia canadensis	01	10	01	--	15	01	15	20	.5	01
Symphoricarpos albus	--	--	--	--	03	.5	10	--	.5	--
HERB-DWARF SHRUB LAYER										
Achillea millefolium	01	.5	.5	.5	01	.5	.5	--	--	05
Anemone multifida	03	--	--	--	--	.5	.5	--	--	--
Arctostaphylos uva-ursi	25	--	.5	--	--	.5	15	02	--	--
Arnica cordifolia	--	01	.5	--	--	--	--	02	--	--
Aster ciliolatus	.5	01	01	--	02	02	.5	--	--	--
Aster conspicuus	.5	.5	--	.5	25	03	02	03	--	--
Bromus pumpellianus	--	--	01	--	--	10	05	--	--	--
Calamagrostis canadensis	--	--	--	--	30	--	--	--	--	--
Calamagrostis rubescens	--	--	--	--	--	--	--	15	--	--
Castilleja miniata	--	.5	02	--	.5	.5	--	.5	--	--
Cornus canadensis	--	01	--	02	--	--	--	--	.5	--
Elymus innovatus	45	15	60	20	15	40	18	--	10	20
Fragaria virginiana	02	01	--	--	03	05	01	--	01	10
Galium boreale	01	.5	.5	--	03	.5	08	--	.5	03
Hedysarum alpinum	--	--	.5	--	01	--	--	01	--	--
Lathyrus ochroleucus	02	02	01	.5	08	08	02	03	02	15
Linnaea borealis	--	05	--	02	--	--	.5	02	--	--
Mertensia paniculata	--	.5	--	.5	--	--	--	--	--	.5 05
Oxytropis deflexa	15	.5	--	--	--	.5	--	--	--	--
Pyrola secunda	.5	.5	--	.5	.5	--	.5	--	.5	--
Senecio indecorus	0e	--	--	--	03	01	.5	--	--	--
Vicia americana	01	.5	01	--	03	12	--	.5	02	--
BRYOID LAYER										
Drepanocladus uncinatus	--	--	--	--	--	--	.5	.5	--	--
Hylocomium splendens	--	--	--	03	--	--	.5	--	--	--
Peltigera aphthosa	--	--	--	--	--	--	.5	.5	--	--
Peltigera canina	--	--	--	01	--	--	.5	--	--	--
Pylaisiella polyantha	--	--	--	--	--	--	--	.5	.5	--
Thuidium abietinum	02	--	--	--	--	--	.5	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Stands of C16 are 60 to 120 years old and are intermediate to mature successionally. *Populus tremuloides* regeneration is common in many stands, while others have small amounts of *Picea glauca*, suggesting an increase in *Picea glauca* if the stand remains undisturbed.

The C16 v.t. differs from C22 in occurring on gentler slopes and on fluvial rather than colluvial landforms. *Lathyrus ochroleucus* and *Galium boreale* have higher cover in C16 than C22 and *Aster conspicuus*, while frequently present, has low cover in C16.

Other Studies: In Jasper, Hettinger (1975, *Populus tremuloides* type) and La Roi (1975, *Populus tremuloides* types) have described similar types. In both Banff and Jasper, Lulman (1976) described three *Populus tremuloides* dominated types which collectively constitute most of C16. In other parts of Alberta, similar types have been described by Jeffrey et al. (1968), Kondla (1978) in Kananaskis Provincial Park (aspen/hairy wild rye-bearberry), Kuchar (1973) in Waterton Lakes National Park (poplar forest), Ogilvie (1963, *Populus tremuloides* type), Mackenzie-Grieve (1970) for the Red Deer River valley east of Banff (*Populus/Elymus-Aster*), Ogilvie (1971) for the Porcupine Hills (aspen type), Moss (1955, aspen consociation of the *Populus* association) and, in the northern foothills by Corns (1978, *Populus tremuloides/Viburnum edule/Rubus pubescens*). In the Cypress Hills of Saskatchewan and Alberta, Newsome and Dix (1968) have described *Populus tremuloides* dominated forests which are similar to C16. Douglas (1974) has described a similar *Populus tremuloides/Arctostaphylos uva-ursi* type from the southwestern Yukon. In British Columbia, similar types have been described by Beil (1974, *Populus tremuloides/Rosa acicularis*), Kuchar (1978) in Yoho National Park (aspen-balsam poplar forest), and by Tisdale and McLean (1957, *Populus tremuloides/Calamagrostis*).

The C16 v.t. is also related to a group of types which extend south along the lower elevations of the Rocky Mountains in the United States. These include *Populus tremuloides/Symphoricarpos albus* in northwestern Montana (Lynch 1955), *P. tremuloides/Lupinus argenteus* in northern Wyoming (Hoffman and Alexander 1976), and *Populus tremuloides/Symphoricarpos oreophilus* in southern Wyoming (Reed 1971) and southern Colorado (Langenheim 1962, Morgan 1969).

C17: *Populus balsamifera/Shepherdia canadensis*

(balsam poplar/buffaloberry)

Environment: The C17 v.t. occurs on predominantly mesic Montane to Lower Subalpine (1000-1530 m), gently sloping (<25%) sites on various aspects. Soils are rapidly to moderately well drained Regosols developed on fluvial landforms.

Vegetation: *Populus balsamifera* (15-50%) is the dominant tree (Table 25, Plate 19). *Picea glauca* (<10%) occurs in many plots. The shrub layer has moderate to high cover

(20-80%), dominated by *Shepherdia canadensis* (10-70%), *Populus balsamifera* regeneration (<10%), *Rosa acicularis* (<5%), and *Cornus stolonifera* (<10%). The herb-dwarf shrub layer usually has moderate cover (25-60%) and is dominated by *Elymus innovatus* (10-30%) with lesser amounts of *Fragaria virginiana* (<3%), *Linnaea borealis* (<10%), *Aster ciliolatus* (<5%), and *Epilobium angustifolium* (<1%). The bryoid layer has low cover (<10%) with no high frequency of species. Epiphytes are sparse.

Table 25 Stands representing the balsam poplar / buffaloberry (C17) v.t.

	AW	IC	IC	JC	JC	JD	JD	SJ	SJ
	51	50	51	70	70	60	90	70	90
	25	81	40	06	11	33	06	22	31
TREE LAYER									
Picea glauca	03	05	--	10	12	15	02	22	07
Picea mariana	--	--	--	--	05	--	--	--	--
Pinus contorta	02	--	--	05	--	--	.5	--	--
Populus balsamifera	12	45	40	45	56	40	18	15	07
Populus tremuloides	--	--	05	--	--	--	--	--	--
Pseudotsuga menziesii	01	--	--	--	--	--	--	--	--
TALL SHRUB LAYER									
Alnus tenuifolia	--	--	05	--	--	--	--	03	--
Picea glauca	01	--	--	03	.5	05	15	12	03
Picea mariana	--	--	--	--	03	--	--	--	--
Populus balsamifera	--	--	--	05	--	02	01	--	--
Populus tremuloides	03	--	--	--	--	--	--	--	--
Pseudotsuga menziesii	02	--	--	--	--	--	--	--	--
Salix scouleriana	--	--	05	--	02	--	--	--	--
SHRUB LAYER									
Alnus crispa	--	--	--	10	--	--	--	--	--
Alnus tenuifolia	--	.5	--	--	02	--	--	--	--
Amelanchier alnifolia	.5	--	--	01	--	--	--	02	--
Cornus stolonifera	--	.5	.5	02	.5	--	--	10	--
Juniperus communis	02	--	.5	--	.5	--	--	--	--
Ledum groenlandicum	--	--	--	--	08	--	--	--	--
Lonicera involucrata	--	.5	03	--	.5	--	--	--	--
Picea glauca	--	--	.5	--	01	02	02	15	08
Populus balsamifera	01	--	--	--	02	10	03	02	02
Rosa acicularis	.5	.5	--	05	06	.5	--	05	04
Salix myrtillifolia	--	--	--	--	10	--	--	--	--
Salix spp.	--	--	--	--	01	25	--	--	--
Shepherdia canadensis	04	70	10	25	21	--	70	10	11
Symphoricarpos albus	--	--	--	--	--	--	--	04	--
Viburnum edule	.5	--	.5	02	02	--	--	--	--
HERB-DWARF SHRUB LAYER									
Achillea millefolium	.5	--	--	--	--	--	.5	01	--
Arctostaphylos uva-ursi	35	03	--	--	02	--	--	02	--
Aster ciliolatus	.5	--	01	--	02	.5	--	05	--
Aster conspicuus	.5	.5	--	01	.5	--	--	--	--
Carex aquatilis	--	--	--	--	05	--	--	--	--
Carex media	--	--	--	--	30	--	--	--	--
Cornus canadensis	--	--	01	05	--	--	--	--	--
Elymus innovatus	.5	--	30	15	50	--	20	--	12
Epilobium angustifolium	--	.5	.5	.5	.5	--	.5	--	--
Equisetum arvense	--	--	02	--	05	03	--	--	--
Equisetum pratense	--	--	--	--	03	--	--	--	--
Equisetum sciripoides	--	--	02	.5	--	--	--	--	.5
Fragaria virginiana	.5	.5	--	.5	01	.5	01	03	--
Hedysarum alpinum	--	--	--	--	02	--	--	02	05
Lathyrus ochroleucus	--	01	.5	--	--	--	--	--	02
Linnaea borealis	--	.5	10	01	--	--	05	01	--
Mertensia paniculata	--	--	.5	03	01	--	--	--	05
Mitella nuda	--	--	.5	--	.5	.5	.5	--	--
Petasites palmatus	--	--	.5	.5	01	--	.5	--	--
Poa pratensis	--	--	--	--	--	15	--	--	--
Pyrola secunda	--	.5	.5	--	--	--	.5	.5	--
Ranunculus acris	--	--	--	--	--	20	--	--	--
Rubus pubescens	--	01	--	.5	01	.5	--	--	--
Smilacina racemosa	--	--	--	--	--	--	--	03	--
Smilacina stellata	--	--	--	--	--	.5	.5	--	.5	--
Taraxacum officinale	--	--	--	--	--	40	--	01	--
Trifolium repens	--	--	--	--	--	05	--	--	--
Vaccinium vitis-idaea	--	--	--	--	10	--	--	--	--
Vicia americana	--	.5	.5	--	--	.5	--	--	.5
BRYOID LAYER									
Brachythecium spp.	--	.5	--	10	--	--	--	--	--
Hylocomium splendens	--	--	--	.5	--	--	01	--	--
Hypnum revolutum	--	.5	--	--	--	--	--	.5	.5
Peltigera canina	--	.5	--	.5	--	--	--	.5	--
Pylaisiella polyantha	--	--	--	--	--	--	05	.5	--
Tortula ruralis	--	.5	--	.5	--	--	--	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Successionally, C17 is early to intermediate. Abundant *Picea glauca* is often present, indicating possible succession to a *Picea glauca* dominated v.t., possibly C26.

The C17 v.t. is distinguished from C28 by occurring on drier sites with *Equisetum* spp. cover <5%.

Other Studies: The dry phase of the *Populus balsamifera* type described by Douglas (1974) in southwestern Yukon is similar, the major difference being the presence of *Lupinus arcticus* in the Yukon type. Kondla (1978) described a similar balsam poplar forest in Kananaskis Provincial Park, Alberta.

C18: *Pinus contorta/Shepherdia canadensis/ Vaccinium scoparium*

(lodgepole pine/buffaloberry/grouseberry)

Environment: The C18 v.t. occurs on mesic Lower Subalpine sites (1500-2020 m) on various slopes and all aspects. The soils are well drained Eutric Brunisols, less often Dystric Brunisols and Brunisolic Gray Luvisols, developed primarily on glacial landforms.

Vegetation: The tree layer is closed (25-55%) and dominated by *Pinus contorta* (25-50%) with *Picea* spp. (3-5%) often present (Table 26). *Shepherdia canadensis* (10-30%) dominates the moderately dense (15-40%) shrub layer (Plate 20). Also common is *Juniperus communis* (1-5%). The herb-dwarf shrub layer, with a total cover of 25 to 45%, is dominated by *Vaccinium scoparium* (20-45%). *Elymus innovatus* (5-25%), *Linnaea borealis* (3-10%), *Arnica cordifolia* (1-5%), *Cornus canadensis* (1-3%), and *Arctostaphylos uva-ursi* (1-2%) are common. *Pyrola secunda* and *Epilobium angustifolium* occur with high frequency but low cover. The bryoid layer has a cover of 30 to 65% and is dominated by *Pleurozium schreberi* (20-40%) and *Hylocomium splendens* (5-15%). *Dicranum* spp. (1-3%), *Peltigera aphthosa* (2-5%), and *Cladonia* spp. (1-2%) are also common. Epiphytes are scarce with *Letharia vulpina*, *Cetraria pinastri*, and *Alectoria* spp. most frequent.

Tree regeneration is predominantly *Picea* spp. Stands are mostly 60 to 100 years old and of fire origin. Thus, C18 is intermediate to advanced successionally. Further succession to C13 appears likely, although this is not clear.

The C18 v.t. is closely related to C6 and C19 and intergrading stands occur (Table 12). The C18 v.t. is distinguished from both by having *Vaccinium scoparium* dominant in the herb-dwarf shrub layer rather than *Aster conspicuus* (C6) or *Linnaea borealis* (C19). C18 often occurs at altitudes immediately above C19 and is distinguished from C15

by being dominated by *Pinus contorta* rather than *Picea engelmannii*.

Table 26 Stands representing the lodgepole pine / buffaloberry / grouseberry (C18) v.t.

	AW	IC	IC	JC	JD	JM	KS	LC	PA	SJ
	70	60	80	70	70	70	60	91	81	70
	67	25	51	85	87	30	11	86	21	35
TREE LAYER										
Picea engelmannii	--	--	--	04	.5	--	--	--	05	--
Pinus contorta	40	40	30	25	25	30	40	45	45	25
TALL SHRUB LAYER										
Picea engelmannii	--	--	--	--	--	--	--	15	05	.5
Pinus contorta	--	--	.5	--	40	01	.5	--	10	--
SHRUB LAYER										
Juniperus communis	02	.5	.5	01	01	.5	01	--	03	02
Ledum glandulosum	--	--	--	--	--	--	.5	--	--	--
Ledum groenlandicum	02	.5	--	--	01	01	--	05	--	--
Picea engelmannii	--	--	.5	--	.5	.5	.5	05	05	--
Pinus contorta	.5	--	--	--	15	--	01	--	.5	--
Rosa acicularis	04	--	01	--	--	.5	.5	02	--	--
Salix glauca	02	--	.5	--	05	--	--	--	--	--
Shepherdia canadensis	12	55	24	05	15	07	50	25	25	30
HERB-DWARF SHRUB LAYER										
Achillea millefolium	.5	--	--	.5	.5	--	--	--	.5	--
Arctostaphylos uva-ursi	02	--	01	--	35	--	01	--	--	--
Arnica cordifolia	03	10	02	02	.5	07	03	--	10	10
Aster conspicuus	01	10	--	--	--	.5	.5	--	--	--
Castilleja miniata	--	--	.5	--	.5	--	.5	--	--	--
Cornus canadensis	--	02	--	--	--	03	02	--	--	03
Elymus innovatus	06	03	11	01	50	06	08	12	05	01
Empetrum nigrum	--	.5	--	03	--	01	--	--	--	03
Epilobium angustifolium	09	01	.5	.5	--	01	03	02	.5	02
Linnaea borealis	10	05	04	05	05	10	03	10	--	10
Pyrola secunda	.5	01	--	.5	.5	.5	.5	01	--	--
Vaccinium scoparium	20	15	08	20	25	40	40	18	50	25
Vaccinium vitis-idaea	01	.5	.5	--	--	--	--	03	--	--
BRYOID LAYER										
Brachythecium spp.	01	--	--	.5	--	--	--	--	05	--
Cladonia spp.	09	--	.5	.5	.5	02	03	03	.5	.5
Dicranum scoparium	--	--	.5	02	--	--	--	--	--	--
Drepanocladus uncinatus	--	--	.5	--	01	--	.5	--	10	--
Hylocomium splendens	--	40	20	--	--	.5	--	10	--	--
Peltigera aphthosa	--	02	01	01	.5	.5	02	10	05	04
Pleurozium schreberi	--	40	10	.5	03	70	20	20	40	15
Ptilium crista-castrensis	--	--	05	--	.5	05	--	25	--	.5
EPIPHYTES										
Bryoria glabra	--	--	--	.5	--	--	--	--	--	.5
Cetraria pinastri	--	--	.5	.5	--	.5	--	.5	--	.5
Letharia vulpina	--	--	--	.5	--	.5	--	.5	--	.5
Parmeliopsis ambigua	--	--	.5	.5	--	--	--	--	--	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Other Studies: Similar types have been described in Alberta by Kondla (1978) in Kananaskis Provincial Park (pine/grouseberry, pine/grouseberry-wild rye) and by Cormack (1953). In British Columbia, the *Pinus contorta/Vaccinium scoparium* and *Pinus contorta/Calamagrostis-Vaccinium scoparium* types of Illingworth and Arlidge (1960) are similar. Pfister et al. (1977) described similar *Pinus contorta* dominated, seral stages of the *Picea/Linnaea borealis* type where *Shepherdia canadensis* and *Vaccinium scoparium* are abundant. In northern Wyoming, *Pinus contorta* dominated, seral stands of the *Picea engelmannii/Vaccinium scoparium*, *Abies lasiocarpa/Vaccinium scoparium*, and *Abies lasiocarpa/Shepherdia canadensis* types (Hoffman and Alexander 1976) are similar to C18. The *Pinus contorta/Vaccinium scoparium* type (Hoffman and Alexander 1976) differs in having little or no *Shepherdia canadensis*. In southern Wyoming, Wirsing and Alexander (1975) described a similar *Pinus contorta/Vaccinium scoparium* type.

C19: *Pinus contorta/Shepherdia canadensis/Linnaea borealis*

(lodgepole pine/buffaloberry/twinflower)

Environment: The C19 v.t. occurs on mesic Montane to Lower Subalpine sites (1200-2000 m) on various slopes of southerly and westerly aspect. The soils are well drained Eutric Brunisols more often than Dystric Brunisols and Gray Luvisols. They are developed primarily on glacial landforms.

Vegetation: *Pinus contorta* (30-50%) dominates the closed tree layer (Table 27, Plate 21). *Picea* spp. occur frequently but with low cover, usually 1 to 10%. The moderately dense shrub layer (15-35%) is dominated by *Shepherdia canadensis* (10-30%). *Juniperus communis* (1-3%) and *Rosa acicularis* (<1-2%) are frequently present also. The herb-dwarf shrub layer has a total cover of 15 to 30% and is dominated by *Linnaea borealis* (10-25%) and *Elymus innovatus* (3-15%) or *Calamagrostis rubescens*. *Arnica cordifolia* (1-3%) and *Arctostaphylos uva-ursi* (1-3%) are often present, and *Aster conspicuus*, *Cornus canadensis*, *Pyrola secunda*, *Epilobium angustifolium*, and *Fragaria virginiana* occur with high frequency but low cover. The bryoid layer has a cover of 25 to 50% and is dominated by *Hylocomium splendens* (20-40%), *Pleurozium schreberi* (20-35%), and *Peltigera aphthosa* (1-3%). Epiphytes are generally scarce with *Letharia vulpina*, *Cetraria pinastri*, and *Alectoria* spp. most common.

Most C19 stands are 60 to 100 years old and are of fire origin. Tree regeneration is preponderantly *Picea* spp. and thus, C19 is intermediate to advanced successionally. Further successional development paths are not clear. However, succession to C31, C13 or C37 appears likely.

The C19 v.t. is closely related to C3, C6, and C18. Intergrading stands occur and Table 12 compares C19 and four other *Pinus contorta* v.t.s. C19 differs from the other v.t.s in having the herb-dwarf shrub layer dominated by *Linnaea borealis* rather than *Aster conspicuus* (C6), *Vaccinium scoparium* (C18), *Vaccinium caespitosum* (C9) or *Arctostaphylos uva-ursi* (C3). The C3 and C9 v.t.s also differ in having lower *Shepherdia canadensis* cover and C3 has higher *Juniperus communis* cover and *Pinus contorta* regeneration.

Other Studies: In Alberta, similar types have been described by Hettinger (1975) in northern Jasper (seral stage of *Pseudotsuga men-*

Table 27 Stands representing the lodgepole pine / buffaloberry / twinflower (C19) v.t.

	AM	IC	IC	JD	JN	KS	LC	PA	PA	SJ
	70	80	90	80	80	50	90	71	81	90
	18	14	41	78	84	02	31	05	05	53
TREE LAYER										
Picea engelmannii	--	--	01	--	--	--	05	--	10	--
Picea glauca	02	03	--	--	--	03	--	--	--	--
Pinus contorta	55	33	30	30	40	33	35	55	40	45
TALL SHRUB LAYER										
Picea engelmannii	--	--	02	.5	--	--	--	03	05	--
Picea glauca	04	01	--	--	--	.5	--	--	--	--
Pinus contorta	--	--	--	.5	.5	--	--	02	05	02
SHRUB LAYER										
Juniperus communis	02	--	01	.5	01	02	13	10	--	.5
Picea engelmannii	--	--	--	.5	01	--	--	--	05	--
Picea glauca	02	.5	--	--	--	03	--	--	--	03
Pinus contorta	--	--	--	.5	--	--	02	--	05	.5
Rosa acicularis	01	--	01	--	--	01	03	--	05	--
Shepherdia canadensis	45	25	12	40	07	60	35	07	15	08
HERB-DWARF SHRUB LAYER										
Achillea millefolium	--	--	.5	.5	--	.5	.5	--	--	--
Arctostaphylos uva-ursi	--	03	01	20	01	.5	--	--	.5	--
Arnica cordifolia	--	03	03	10	07	02	03	35	10	03
Aster conspicuus	03	--	.5	02	--	01	02	05	--	--
Carex concinna	--	.5	.5	--	.5	01	02	--	--	--
Elymus innovatus	05	18	08	30	08	05	10	15	20	01
Epilobium angustifolium	.5	01	.5	.5	.5	02	--	--	.5	01
Equisetum scirpoides	--	.5	.5	--	.5	--	--	--	--	--
Fragaria virginiana	--	--	.5	--	--	01	01	--	.5	--
Linnaea borealis	30	07	04	15	10	04	30	10	01	20
Pyrola secunda	--	01	.5	--	01	01	--	.5	--	03
Pyrola virens	.5	.5	--	.5	--	--	--	01	--	--
Vaccinium caespitosum	--	--	.5	--	02	--	--	--	--	01
Zygadenus elegans	.5	01	.5	.5	.5	--	01	01	--	--
BRYOID LAYER										
Brachythecium salebrosum	--	--	--	10	--	--	--	--	--	--
Cladonia spp.	--	01	01	.5	02	.5	02	--	03	10
Dicranum scoparium	--	--	01	--	--	.5	--	01	10	--
Drepanocladus uncinatus	05	--	.5	05	--	.5	03	--	--	--
Hylocomium splendens	30	45	02	--	20	05	.5	30	15	01
Peltigera aphthosa	01	02	02	.5	01	.5	--	05	--	03
Pleurozium schreberi	55	30	40	--	05	50	10	30	--	65
Ptilium crista-castrensis	--	.5	01	--	.5	--	--	15	--	01
EPIPHYTES										
Bryoria glabra	--	.5	--	--	--	.5	--	--	.5	--
Cetraria merrillii	--	.5	.5	--	--	--	--	--	--	.5
Cetraria pinastri	--	.5	--	--	.5	.5	--	--	--	.5
Letharia vulpina	--	--	--	--	--	.5	.5	--	.5	.5
Parmeliopsis ambigua	--	--	--	--	.5	.5	--	--	--	.5
Usnea scoredifera	--	.5	.5	--	--	.5	--	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

ziesii/Elymus) and by La Roi (1975, *Pinus contorta/Shepherdia canadensis/Rosa acicularis/Cornus canadensis/Linnaea borealis/Hylocomium splendens*, *Pinus contorta/Shepherdia canadensis/Lathyrus ochroleucus/Linnaea borealis/Pleurozium schreberi*, *Pinus contorta/Shepherdia canadensis/Elymus innovatus/Linnaea borealis/Peltigera canina*). In the Kananaskis area, Kondla (1978) described similar types: pine/twinflower, pine/buffaloberry-twinflower, and pine/buffaloberry-feathermoss. Cormack (1953) described similar vegetation from the southern Alberta foothills as seral to spruce-fir climax. Kuchar's (1978) types (lodgepole pine/buffaloberry/twinflower-bunchberry, lodgepole pine-spruce/buffaloberry/twinflower-bunchberry) from Yoho National Park bear strong similarity, while farther south, the seral stage of Pfister et al. (1977, *Picea/Linnaea borealis*) is very similar.

C20: *Pinus contorta/Menziesia glabella/Vaccinium scoparium*

(lodgepole pine/false azalea/grouseberry)

Environment: The C20 v.t. occurs on mesic Lower Subalpine (1400-1950 m J; 1550-2050 m B) level to steeply sloping sites with northerly and easterly aspects. Soils are well drained Eutric and Dystric Brunisols developed primarily on morainal and, to a lesser extent, on glaciofluvial landforms.

Vegetation: *Pinus contorta* (15-65%) is the dominant tree (Table 28). *Picea engelmannii* (<10%) and *Abies lasiocarpa* (<10%) are present in about one-half of the stands sampled with cover of <10% each. The shrub layer (Plate 22) is dense (30-70%) and is dominated by *Menziesia glabella* (10-70%), *Ledum groenlandicum* (<10%), and *Shepherdia canadensis* (<10%). *Rhododendron albiflorum*, (usually <10%) may occasionally achieve dominance to the exclusion of *Menziesia glabella*, particularly at higher elevations where precipitation is abundant. The herb-dwarf shrub layer usually has abundant cover (25-65%) and is dominated by *Vaccinium scoparium* (10-40%). *Vaccinium membranaceum* (10-35%) substitutes for *Vaccinium scoparium* in northern Jasper beyond the range of the latter. Other common representatives of this layer are *Linnaea borealis* (<10%), *Arnica cordifolia* (<15%), *Cornus canadensis* (<5%), *Elymus innovatus* (<5%), *Epilobium angustifolium* (<1%), and *Pyrola secunda* (<1%). The bryoid layer is well developed (30-90%) and dominated by *Pleurozium schreberi* (25-70%), *Hylocomium splendens* (10-40%), and *Ptilium crista-castrensis* (<10%). *Peltigera aphthosa* (<5%), *Barbilophozia lycopodioides* (<5%), and *Cladonia ecmocyna* (<5%) are also common. *Letharia vulpina* and *Alectoria* spp. are common epiphytes.

Successionally C20 is intermediate with most stands <150 years old.

The C20 v.t. is distinguished from C14 by having dominance of *Pinus contorta* rather than *Picea engelmannii* and from C18 by having dominance in the shrub layer of *Menziesia glabella* rather than *Shepherdia canadensis*. The C20 v.t. is normally seral to C14 but stands with abundant *Rhododendron albiflorum* and *Vaccinium membranaceum* may be seral to C21.

Other Studies: In Banff, Trottier and Scotter (1973) described a similar *Pinus contorta/Vaccinium scoparium* type and, in Jasper, La Roi (1975) has described a *Pinus contorta/Abies lasiocarpa/Menziesia glabella/Vaccinium scoparium/Pleurozium schreberi* type. In Banff and Jasper, La Roi and Hnatuik (1980) described a *Pinus contorta/Menziesia glabella/Vaccinium scoparium* type. Elsewhere

Table 28 Stands representing the lodgepole pine / false azalea / grouseberry (C20) v.t.

	AM	AM	GM	IC	JC	JD	JE	JM	LC	PA
	90	91	60	60	60	80	91	81	91	91
	18	78	41	28	08	22	39	11	98	02
TREE LAYER										
Abies lasiocarpa	--	06	--	05	08	--	06	--	--	--
Picea engelmannii	--	04	--	05	23	.5	04	01	07	05
Pinus contorta	90	30	20	40	25	25	30	32	28	40
TALL SHRUB LAYER										
Abies lasiocarpa	--	02	05	10	05	--	04	--	--	--
Alnus crispa	04	--	--	--	--	--	01	--	--	10
Picea engelmannii	04	04	05	10	03	01	07	--	--	.5
Pinus contorta	--	--	05	--	--	01	04	01	--	--
SHRUB LAYER										
Abies lasiocarpa	01	18	07	15	03	.5	01	01	--	--
Juniperus communis	--	.5	--	--	01	--	01	--	--	--
Ledum groenlandicum	--	04	03	01	--	02	06	.5	--	--
Menziesia glabella	35	25	60	30	25	65	60	60	90	60
Picea engelmannii	--	02	05	10	01	03	02	--	--	--
Rhododendron albiflorum	--	--	--	02	--	--	09	02	10	05
Ribes lacustre	--	--	02	--	.5	--	--	--	--	--
Salix glauca	--	--	--	--	--	.5	--	02	--	--
Shepherdia canadensis	15	03	05	01	--	02	--	10	03	--
HERB-DWARF SHRUB LAYER										
Abies lasiocarpa	--	--	03	--	--	--	.5	--	--	--
Antennaria racemosa	--	--	--	--	--	--	--	03	--	--
Arnica cordifolia	02	01	03	--	--	10	--	03	30	05
Cornus canadensis	01	03	--	.5	.5	.5	01	31	05	--
Elymus innovatus	--	.5	--	05	.5	--	03	01	03	--
Empetrum nigrum	--	01	--	01	.5	02	02	.5	--	--
Epilobium angustifolium	.5	.5	--	--	--	--	.5	.5	.5	--
Fragaria virginiana	.5	01	--	--	--	--	--	--	--	--
Linnaea borealis	02	01	02	02	.5	--	02	02	--	.5
Pedicularis bracteosa	--	--	--	--	--	--	--	01	05	--
Picea engelmannii	--	--	02	--	--	--	--	--	--	--
Pyrola secunda	05	.5	--	.5	01	.5	--	01	01	--
Pyrola virens	--	--	--	.5	.5	--	--	.5	--	--
Rubus pedatus	--	--	--	--	--	--	--	--	--	03
Vaccinium membranaceum	--	--	--	--	.5	--	15	--	05	10
Vaccinium myrtillus	05	--	15	--	--	--	--	.5	--	--
Vaccinium scoparium	30	03	02	05	--	25	--	12	--	--
Vaccinium vitis-idaea	--	--	--	01	.5	--	02	--	02	--
Equisetum scirpoides	--	--	02	--	--	.5	--	01	01	--
Lycopodium annotinum	--	--	--	--	--	05	--	--	--	02
BRYOID LAYER										
Brachythecium spp.	--	04	--	--	--	--	--	15	--	--
Cladonia cornuta	--	--	--	--	--	--	.5	.5	--	--
Cladonia ecmocyna	--	--	01	--	--	--	01	--	--	--
Cladonia gonecha	--	--	--	--	--	--	.5	.5	--	--
Cladonia gracilis	--	--	--	--	--	--	01	.5	--	--
Cladonia phyllophora	--	--	--	--	--	--	01	.5	--	--
Cladonia pyxidata	--	--	--	--	--	--	.5	.5	--	--
Cladonia spp.	35	12	--	.5	.5	05	--	--	.5	--
Dicranum fuscescens	--	--	03	--	--	--	--	--	--	--
Dicranum muehlenbeckii	--	--	--	--	--	--	02	--	--	--
Dicranum scoparium	--	--	--	--	--	--	03	--	--	--
Dicranum spp.	02	03	--	01	.5	.5	--	--	--	--
Hylocomium splendens	--	--	25	45	85	05	24	05	--	--
Peltigera aphthosa	--	02	02	03	02	02	01	.5	--	10
Peltigera canina	--	--	--	--	--	--	.5	.5	--	--
Pleurozium schreberi	20	62	17	35	06	75	22	25	35	50
Polytrichum juniperinum	02	.5	--	--	--	--	--	--	--	--
Ptilium crista-castrensis	02	01	02	05	.5	--	01	05	--	15
Stereocaulon tomentosum	--	--	--	--	--	--	01	.5	--	--
Barbilophozia hatcheri	--	08	--	--	--	--	--	.5	--	--
Barbilophozia lycopodioides	--	--	03	--	--	--	10	15	--	--
EPIPHYTES										
Alectoria spp.	.5	.5	--	--	.5	.5	--	--	--	.5
Cetraria pinastri	--	--	--	--	--	--	.5	.5	--	--
Letharia vulpina	--	--	--	--	.5	--	--	.5	--	.5
Parmeliopsis ambigua	--	--	--	--	--	--	.5	.5	--	--
Parmeliopsis hyperopta	--	--	--	--	--	--	.5	.5	--	--
Usnea spp.	--	--	--	--	.5	--	.5	--	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

in Alberta, Ogilvie (1963, *Pinus contorta/ Menziesia ferruginea-Lycopodium annotinum*), Kondla (1978) in Kananaskis Provincial Park (pine/false azalea), and Corns (1978), in the northern foothills *(Pinus contorta/Menziesia glabella/Rubus pedatus)* have described similar types. In British Columbia, Kuchar (1978) described a lodgepole pine-spruce/menziesia/ grouseberry type from Yoho National Park.

C21: ***Picea engelmannii-Abies lasiocarpa/Vaccinium membranaceum/Barbilophozia lycopodioides***

(Engelmann spruce-subalpine fir/tall bilberry/ liverwort)

Environment: The C21 v.t. occurs on predominantly mesic Lower to Upper Subalpine (1650-2000 m J, 1750-2250 m B), gently to steeply sloping sites on various aspects in western Banff and Jasper. Soils are well drained Dystric and Eutric Brunisols, and Orthic Humo-Ferric Podzols developed on morainal and colluvial landforms.

Vegetation: *Picea engelmannii* (5-35%) is the dominant tree (Plate 23), while *Abies lasiocarpa* has generally <20% cover (Table 29). *Larix lyallii* occurs sporadically in some Banff stands. The shrub layer has low to high cover (5-70%), dependent largely upon the abundance of *Rhododendron albiflorum* (10-60%). *Abies lasiocarpa* (5-20%) regeneration is common in the shrub layer. The herb-dwarf shrub layer has moderate to high cover (20-70%) and is dominated by *Vaccinium membranaceum* (5-35%), *Vaccinium scoparium* (<15%), *Phyllodoce empetriformis* (<10%), *Empetrum nigrum* (<10%), and *Arnica cordifolia* (<5%). The bryoid layer generally has high cover (30-90%) and is dominated by *Pleurozium schreberi* (15-50%), *Barbilophozia lycopodioides* (5-40%), and *Dicranum scoparium* (<15%). *Peltigera aphthosa* (<5%) and *Cladonia ecmocyna* (<5%) are common. *Letharia vulpina* and *Parmeliopsis ambigua* are common epiphytes.

Successionally C21 is mature with many stands >300 years old.

The C21 v.t. is distinguished from C14 by abundant *Rhododendron albiflorum* and *Vaccinium membranaceum* rather than *Menziesia glabella* and *Vaccinium scoparium*, and C21 occurs at generally higher elevation. The C21 v.t. is distinguished from C15 by a shrub layer dominated by *Rhododendron albiflorum* and *Vaccinium membranaceum* instead of *Vaccinium scoparium*. Stands transitional to C14 and C15 occur. The C21 v.t. is distinguished from C24 by the usual absence of *Salix vestita* and *Cassiope tetragona*.

Other Studies: In Alberta, similar types have been desribed by Corns (1978) from the northern foothills (*Picea-engelmannii-Abies lasiocarpa/Menziesia glabella*), Beil (1966) for Jasper and Banff, Baig (1972) for Alberta Rockies (*Abies-Picea-Larix/Rhododenron*), and Trottier and Scotter (1973) for Banff (*Picea-Abies/Rododenron albiflorum-Vaccinium* ssp.). Kuchar (1978) described a similar spruce-fir/rhododendron type in Yoho National Park and similar vegetation occurs at

Table 29 Stands representing the Engelmann spruce-subalpine fir / tall bilberry / liverwort (C21) v.t.

	AW 60 91	CC 60 83	IC 70 89	JC 61 02	JD 60 46	JE 90 87	JN 70 67	LC 90 67	PA 90 94	SJ 71 71
TREE LAYER										
Abies lasiocarpa	46	13	12	08	18	10	20	10	10	19
Picea engelmannii	04	17	23	37	27	25	--	05	30	--
Pinus contorta	--	--	--	--	--	--	--	02	--	--
TALL SHRUB LAYER										
Abies lasiocarpa	01	04	08	10	15	03	01	05	10	05
Picea engelmannii	--	02	02	.5	--	02	--	--	05	--
SHRUB LAYER										
Abies lasiocarpa	18	10	15	20	15	06	10	--	05	07
Betula glandulosa	--	--	--	--	--	--	--	08	--	--
Menziesia glabella	--	03	--	--	--	--	--	--	--	--
Picea engelmannii	--	02	02	--	--	02	--	--	--	--
Rhododendron albiflorum	--	60	03	30	.5	--	--	30	15	--
Salix vestita	--	--	--	--	--	--	--	07	--	--
HERB-DWARF SHRUB LAYER										
Aquilegia flavescens	--	04	--	--	01	--	--	--	--	--
Arnica cordifolia	04	06	--	02	10	03	--	05	--	--
Arnica latifolia	--	--	--	--	--	01	--	--	--	10
Artemisia norvegica	--	--	--	--	--	.5	--	03	--	--
Cassiope mertensiana	--	--	--	--	--	--	07	--	--	--
Empetrum nigrum	--	--	--	--	--	--	--	03	15	--
Erigeron peregrinus	--	--	--	--	03	--	--	--	--	--
Erythronium grandiflorum	--	--	--	--	07	--	--	--	--	--
Fragaria virginiana	--	--	--	--	02	--	--	--	--	--
Listera cordata	--	04	--	--	--	.5	--	.5	--	--
Mitella nuda	--	02	--	--	--	--	--	--	--	--
Lycopodium annotinum	--	02	.5	--	--	.5	--	03	--	--
Parnassia montanensis	--	01	--	--	--	--	--	--	--	--
Pedicularis bracteosa	--	--	--	--	--	02	--	01	--	04
Pedicularis contorta	--	--	--	--	13	--	--	--	--	--
Phyllodoce empetriformis	--	01	--	--	--	10	--	.5	--	02
Phyllodoce glanduliflora	--	02	03	07	--	--	--	--	15	--
Pyrola secunda	--	02	--	--	.5	--	--	01	--	02
Rubus pedatus	--	--	--	--	--	--	07	--	--	--
Thalictrum occidentale	--	--	--	--	--	08	01	--	--	--
Vaccinium membranaceum	28	20	12	40	30	19	10	15	30	35
Vaccinium scoparium	02	05	05	12	15	--	--	--	05	03
Valeriana sitchensis	--	25	--	--	07	01	--	--	--	.5
Veratrum eschscholtzii	--	08	--	--	--	.5	--	--	--	--
BRYOID LAYER										
Aulacomnium spp.	--	--	--	--	08	--	--	--	--	--
Barbilophozia hatcheri	05	--	--	15	--	--	10	--	--	--
Barbilophozia lycopodioides	--	--	--	--	02	.5	20	10	20	15
Barbilophozia spp.	--	--	15	--	--	--	--	--	--	--
Cladonia ecmocyna	--	--	--	--	--	03	.5	07	--	.5
Cladonia fimbriata	--	--	--	--	--	--	--	--	--	.5
Cladonia gonecha	--	--	--	--	--	--	.5	03	--	.5
Cladonia spp.	01	--	01	01	--	--	01	.5	--	01
Dicranum brevifolium	--	--	--	--	--	--	--	--	--	--
Dicranum fuscescens	--	--	--	--	--	02	--	15	--	--
Dicranum scoparium	--	--	--	--	--	--	10	--	--	10
Dicranum spp.	28	--	20	12	--	--	--	--	--	--
Hylocomium splendens	--	--	12	08	--	--	--	--	--	--
Peltigera aphthosa	.5	--	01	01	--	02	--	10	05	--
Pleurozium schreberi	--	--	40	55	--	25	.5	--	30	.5
Polytrichum spp.	--	--	--	--	15	--	--	--	--	--
Ptilium crista-castrensis	--	--	--	--	--	--	--	--	05	--
EPIPHYTES										
Alectoria spp.	.5	--	--	.5	.5	--	.5	--	--	--
Letharia vulpina	--	--	--	--	.5	.5	--	--	--	.5
Usnea spp.	--	--	--	.5	.5	--	--	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Logan Pass, Glacier National Park, Montana as reported by Habeck (1969).

C22: ***Populus tremuloides/Elymus innovatus-Aster conspicuus***

(aspen/hairy wild rye-showy aster)

Environment: The C22 v.t. occurs on mesic to subxeric, Montane to Lower Subalpine sites (1200-1800 m) on moderate to very steep (45-70%) slopes of southerly aspect in both Banff and Jasper. The soils are rapidly to well drained Orthic and Humic Regosols and Orthic Eutric Brunisols developed on colluvial and, to a minor extent, on fluvial and glacial landforms.

Vegetation: The tree layer (Plate 24) is dominated by *Populus tremuloides* (20-40%) (Table 30). The trees are often stunted, appearing more as tall shrubs than trees. Some stands are also quite open. The shrub layer is dense (20-50%) with *Populus tremuloides* (10-20%), *Rosa acicularis* (3-20%), and *Shepherdia canadensis* (1-2%). *Juniperus communis* is frequent but with cover <1%. The herb-dwarf shrub layer is also dense (60-80%). *Elymus innovatus* is dominant (20-50%) with lesser amounts of *Aster conspicuus* (5-10%) and *Arctostaphylos uva-ursi* (10-40%). *Fragaria virginiana, Achillea millefolium* , and *Hedysarum sulphurescens* (in Banff) occur with low cover and high frequency. The bryoid layer is very sparse with traces of *Tortula ruralis*. Epiphytes are nearly absent.

Table 30 Stands representing the aspen / hairy wild rye-showy aster (C22) v.t.

	IC 50 65	IC 60 22	JD 70 64	JD 81 26	JD 81 27	JE 80 18	JE 81 13	JE E 34	JM [illegible] [illegible]
TREE LAYER									
Populus tremuloides	25	40	10	65	40	15	20	25	05
SHRUB LAYER									
Amelanchier alnifolia	--	01	--	--	--	--	--	--	10
Juniperus communis	.5	--	10	01	01	.5	02	01	01
Populus tremuloides	--	--	40	05	25	12	02	20	01
Rosa acicularis	--	03	01	--	--	--	--	--	13
Shepherdia canadensis	--	02	.5	02	01	--	--	.5	15
Spiraea lucida	--	05	--	--	--	--	--	--	01
HERB-DWARF SHRUB LAYER									
Achillea millefolium	01	--	01	.5	.5	01	.5	.5	--
Anemone multifida	--	--	.5	--	.5	--	.5	--	--
Arctostaphylos uva-ursi	50	--	35	30	40	05	08	12	02
Artemisia michauxiana	--	--	--	--	--	01	.5	--	--
Aster conspicuus	--	30	10	01	10	--	--	--	01
Campanula rotundifolia	.5	--	.5	.5	.5	.5	.5	.5	--
Castilleja minista	--	--	.5	01	--	--	--	--	01
Elymus innovatus	01	50	30	10	40	20	01	20	05
Epilobium angustifolium	.5	30	.5	--	--	--	--	--	--
Fragaria virginiana	01	03	02	--	.5	--	.5	--	.5
Galium boreale	.5	--	--	--	--	.5	--	.5	--
Hedysarum sulphurescens	--	--	01	05	10	08	--	08	--
Juniperus horizontalis	--	--	--	--	01	--	15	--	--
Koeleria cristata	--	--	--	.5	01	--	--	01	--
Oxytropis splendens	--	--	.5	.5	.5	--	--	--	--
Penstemon procerus	--	--	--	--	.5	01	.5	.5	--
Rosa acicularis	03	--	--	25	05	10	03	05	--
Poa spp.	--	--	--	10	10	.5	--	--	--
Thalictrum venulosum	--	20	--	--	--	--	--	--	01
BRYOID LAYER									
Candellariella aurella	--	--	--	--	--	.5	.5	.5	--
Collema spp.	--	--	--	--	--	.5	.5	--	--
Encalypta spp.	--	--	--	--	.5	.5	--	--	--
Lecanora melanophthalma	--	--	--	--	--	--	.5	.5	--
Peltigera aphthosa	--	--	--	--	.5	--	--	--	--
Peltigera spuria	--	--	--	--	--	.5	.5	--	--
Physcia orbicularis	--	--	--	--	--	--	.5	.5	--
Rhizocarpon disporum	--	--	--	--	--	--	.5	.5	--
Rhizocarpon geographicum	--	--	--	--	.5	--	--	.5	--
Tortula ruralis	--	--	--	--	--	.5	.5	.5	--
Xanthoria elegans	--	--	--	--	--	.5	.5	.5	--
EPIPHYTES									
Caloplaca holocarpa	--	--	--	--	.5	--	--	.5	--
Letharia vulpina	--	--	--	--	--	--	--	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Stands of C22 are 40 to 80 years old and

are intermediate successionally. Frequent disturbance due to colluviation and avalanching is important in maintaining this v.t.

The C22 v.t. differs from C16 in occurring on colluvial rather than fluvial landforms and on steeper slopes. The C22 v.t. generally has higher cover for *Aster conspicuus* and *Hedysarum sulphurescens* than C16, while *Lathyrus ochroleucus* and *Galium boreale* which are prominent in C16, are rare and infrequent in C22.

Other Studies: Baig (1972) has described a *Populus tremuloides/Elymus innovatus* type from Alberta which is similar to C22.

C23: *Larix lyallii-Abies lasiocarpa/Vaccinium scoparium-Antennaria lanata*

(subalpine larch-subalpine fir/grouseberry-everlasting)

Environment: The C23 v.t. occurs on mesic Upper Subalpine (2000-2450 m) gently to steeply sloping sites on various aspects in Banff south of a line running from Hector Lake to the Panther River. Soils are well to moderately well drained Dystric and Eutric Brunisols and Orthic Humo-Ferric Podzols on colluvial and morainal landforms.

Vegetation: *Larix lyallii* (10-60%) is the dominant tree (Plate 25) in this predominantly closed forest v.t. (Table 31). Open forests occur in more severe environments where they are often transitional to other types. *Abies lasiocarpa* (<20%) is also usually present in the tree layer. Shrub cover (15-40%) is primarily of *Abies lasiocarpa* and *Larix lyallii*. The herb-dwarf shrub layer usually has abundant cover (55-90%), the dominants being *Vaccinium scoparium* (5-40%), *Phyllodoce glanduliflora* (<25%), and *Antennaria lanata* (<10%). Other common species include *Erigeron peregrinus* (<5%), *Valeriana sitchensis* (<10%), *Arnica latifolia* (5-20%), *Cassiope mertensiana* (<20%), *Luzula wahlenbergii* (<5%), and *Pedicularis bracteosa* (<2%). The bryoid layer generally has low to moderate cover (<35%) dominated by *Barbilophozia* spp. and *Polytrichum juniperinum* (<5%). *Letharia vulpina* is a common epiphyte.

Successionally, C23 is mature with most stands 100 to 300 years old.

The C23 v.t. is distinguished from all other v.t.s by the dominance of *Larix lyallii*. Open forest stands with *Picea engelmannii* may be transitional to O10 or, where trees are very widely spaced, to L5. Closed forest stands with abundant *Picea engelmannii* may be transitional to C15 or to C21 where *Vaccinium membranaceum* is greater than *Vaccinium scoparium*.

Table 31 Stands representing the subalpine larch-subalpine fir / grouseberry-everlasting (C23) v.t.

	AW	AW	AW	IC	JD	JD	JE	KS	KS	PA
	50	50	51	80	60	60	81	50	51	71
	78	80	35	83	63	86	63	77	20	87
TREE LAYER										
Abies lasiocarpa	--	17	04	01	05	--	07	15	--	--
Larix lyallii	--	21	22	22	25	13	05	65	--	10
Picea engelmannii	--	01	01	04	--	.5	--	--	--	--
TALL SHRUB LAYER										
Abies lasiocarpa	--	06	--	.5	04	.5	03	15	--	.5
Larix lyallii	03	02	--	02	04	20	01	10	--	15
Picea engelmannii	--	.5	--	--	--	.5	--	--	--	--
SHRUB LAYER										
Abies lasiocarpa	--	07	.5	.5	01	01	04	05	15	.5
Larix lyallii	05	--	01	.5	01	10	02	02	05	10
HERB-DWARF SHRUB LAYER										
Anemone occidentalis	.5	.5	01	--	10	01	.5	06	10	02
Antennaria lanata	18	01	--	.5	--	10	05	05	02	15
Arnica cordifolia	--	08	--	02	--	--	.5	--	--	--
Arnica latifolia	--	--	--	--	.5	35	15	--	20	--
Castilleja rhexifolia	--	--	--	--	.8	01	--	--	.5	--
Cassiope mertensiana	--	.5	--	--	--	10	--	03	05	10
Deschampsia atropurpurea	--	--	.5	--	--	.5	--	--	.5	--
Dryas octopetala	--	--	--	--	--	--	--	--	--	--
Erigeron peregrinus	--	--	--	01	15	.5	--	--	02	.5
Erythronium grandiflorum	--	--	--	--	05	--	--	--	--	--
Fragaria virginiana	--	--	.5	.5	--	--	--	--	02	--
Hieracium gracile	.5	.5	--	.5	.5	.5	--	--	--	--
Luzula wahlenbergii	01	--	.5	.5	01	05	--	06	--	.5
Pedicularis bracteosa	--	.5	--	.5	--	.5	--	01	--	--
Pedicularis contorta	--	--	--	--	03	--	--	--	03	--
Phleum alpinum	.5	--	.5	--	.5	.5	.5	--	.5	03
Phyllodoce empetriformis	--	--	--	--	08	07	--	10	--	--
Phyllodoce glanduliflora	28	15	01	05	02	08	40	--	30	35
Poa alpina	02	--	--	--	.5	--	--	--	--	--
Poa cusickii	.5	--	--	--	--	03	--	06	02	--
Potentilla diversifolia	--	--	--	.5	.5	--	--	--	.5	--
Pyrola secunda	--	--	02	.5	--	--	--	--	--	--
Ranunculus eschscholtzii	01	--	.5	--	--	--	--	--	.5	--
Salix arctica	08	--	--	--	--	--	--	--	03	--
Senecio triangularis	--	--	09	--	05	--	.5	--	--	--
Sibbaldia procumbens	02	01	--	.5	--	--	.5	--	.5	.5
Trisetum spicatum	--	--	.5	.5	--	.5	.5	--	.5	.5
Trollius albiflorus	--	--	01	--	03	--	--	--	--	--
Vaccinium scoparium	04	32	01	75	05	30	15	30	06	05
Valeriana sitchensis	--	--	01	--	05	--	01	--	08	01
Veronica alpina	--	--	.5	--	.5	.5	--	--	02	--
BRYOID LAYER										
Barbilophozia lycopodioides	--	12	--	.5	--	--	.5	--	--	--
Barbilophozia spp.	--	--	--	--	--	03	--	--	--	--
Brachythecium spp.	--	--	04	--	--	03	--	--	--	--
Cetraria islandica	--	--	--	.5	--	--	--	--	05	.5
Cladonia spp.	05	04	--	.5	--	05	--	--	--	05
Dicranum scoparium	--	--	--	--	.5	--	--	.5	--	--	05
Dicranum spp.	--	18	--	--	--	05	--	--	--	--
Peltigera aphthosa	--	--	--	01	--	.5	.5	--	--	--
Pogonatum alpinum	--	--	--	--	--	--	--	--	--	02
Polytrichum juniperinum	--	--	01	.5	--	--	--	--	--	--
Polytrichum spp.	25	--	--	--	--	02	.5	03	05	--
EPIPHYTES										
Letharia vulpina	--	.5	--	--	.5	.5	.5	--	--	--
Parmeliopsis ambigua	--	--	--	.5	--	--	.5	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Other Studies: Similar types were described for Alberta by Baig (1972) for the southern Alberta Rocky Mountains (*Larix-Abies-Picea/Veronica americana; Larix-Abies/Luzula*), Jacques and Legge (1974) for the Kananaskis area of Alberta (spruce-fir-alpine larch grouseberry), Ogilvie (1976) for the Alberta Rockies (*Picea-Abies-Larix/Luzula wahlenbergii*), Trottier and Scotter (1973) for Banff (*Abies-Picea-Larix/Vaccinium scoparium/ Phyllodoce* spp.-*Cassiope mertensiana, Larix/Vaccinium scoparium/Trollius albiflorus/Carex nigricans, Abies-Picea-Larix/Phyllodoce* spp./*Vaccinium scoparium/Carex nigricans*), and Kuchar (1973) for Waterton Lakes National Park (fir/alpine larch). Elsewhere, Kuchar (1978)

described alpine larch forest in Yoho National Park, as did Pfister et al. (1977) for Montana (*Larix lyallii-Abies lasiocarpa*).Vegetation described by Arno and Habeck (1972) in the Pacific Northwest of the United States, especially western Montana and in southwestern Alberta appears very similar to the Banff *Larix* forests, although no types per se were recognized.

C24: ***Picea engelmannii-Abies lasiocarpa/Salix vestita/Cassiope tetragona***

(Engelmann spruce-subalpine fir/rock willow/ white mountain heather)

Environment: The C24 v.t. occurs on mesic to subhygric, mostly Upper Subalpine sites (1900-2200 m B, 1850-2100 m J) on moderate to steep slopes of northerly aspect in eastern Banff and Jasper. The soils are Static Cryosols and Eutric Brunisols developed on morainal and to a lesser extent on colluvial landforms. The landform surfaces are often soliflucted. Soil drainage varies from well to poorly drained with most soils moderately well to imperfectly drained.

Vegetation: The often sparse tree layer (15-40%) is dominated by *Picea engelmannii* (10-30%) and *Abies lasiocarpa* (3-10%) (Table 32, Plate 26). The shrub layer has a total cover of 15 to 45% and is dominated by *Salix vestita* (5-30%), *Abies lasiocarpa* (10-20%), and *Picea engelmannii* (1-5%). Herb-dwarf shrub layer cover (15-50%) varies greatly. *Cassiope tetragona* (10-35%), *Phyllodoce glanduliflora* (1-10%), and *Equisetum scirpoides* (2-15%) are dominant with *Pyrola secunda*, *Moneses uniflora*, and *Pedicularis bracteosa* frequently present but with low cover. The dense bryoid layer (30-80%) is dominated by *Hylocomium splendens* (10-50%), *Pleurozium schreberi* (5-30%), *Dicranum scoparium* (5-10%), *Drepanocladus uncinatus* (1-5%), *Barbilophozia lycopodioides* (1-5%), and *Peltigera aphthosa* (1-5%). Also present with low cover are *Cladonia gonecha*, *Peltigera canina*, *Nephroma expallidum*, and *Psoroma hypnorum*. Epiphytes are moderate with *Letharia vulpina*, *Hypogymnia austerodes*, *Cetraria pinastri*, and *Parmeliopsis ambigua* most common.

Stands of C24 are mostly 225 to 300 years old, have abundant *Picea engelmannii* and *Abies lasiocarpa* regeneration and are, thus, mature successionally.

The C24 v.t. is distingushed from C34 by having *Salix vestita* cover >5% and *Equisetum scirpoides* cover usually >2%. The O12 v.t. differs from C24 in generally being more open and having the herb-dwarf shrub layer dominated by *Arctostaphylos rubra* and *Dryas octopetala*. The O14 v.t. differs in being generally more open and having *Pedicularis bracteosa* dominant in the herb-dwarf shrub layer rather than *Cassiope tetragona* or *Phyllodoce glanduliflora*.

Table 32 Stands representing the Engelmann spruce-subalpine fir / rock willow / white mountain heather (C24) v.t.

	JD 80 78	JD 80 99	JB 80 83	JB 90 31	LC 90 02	LC 90 85	PA 80 91	PA 81 52	PA 90 56	PA 91 36
TREE LAYER										
Abies lasiocarpa	03	02	--	05	05	10	--	10	10	.5
Picea engelmannii	17	23	20	15	15	20	20	40	30	20
TALL SHRUB LAYER										
Abies lasiocarpa	03	05	04	08	15	15	--	10	15	05
Picea engelmannii	08	15	01	02	08	05	10	05	--	.5
SHRUB LAYER										
Abies lasiocarpa	10	02	01	20	05	10	--	.5	--	.5
Ledum groenlandicum	.5	--	--	.5	--	--	10	--	05	--
Picea engelmannii	02	01	01	.5	--	--	05	--	--	--
Salix glauca	01	.5	--	--	--	--	05	05	--	05
Salix vestita	45	40	08	30	15	25	--	05	20	20
HERB-DWARF SHRUB LAYER										
Abies lasiocarpa	--	--	--	--	--	08	.5	--	--	--
Cassiope tetragona	35	60	15	25	27	07	55	05	10	20
Elymus innovatus	.5	.5	--	--	--	--	--	.5	--	--
Equisetum scirpoides	15	.5	01	15	02	03	15	15	15	10
Moneses uniflora	.5	.5	.5	--	--	--	--	--	--	--
Ledum groenlandicum	--	--	--	--	--	--	10	--	05	--
Pedicularis bracteosa	--	.5	02	--	--	--	--	--	--	.5
Phyllodoce glanduliflora	10	--	08	--	--	--	--	--	.5	--
Pyrola secunda	.5	.5	--	.5	01	02	.5	.5	.5	.5
BRYOID LAYER										
Aulacomnium palustre	01	.5	--	01	--	03	--	.5	--	--
Barbilophozia lycopodioides	--	--	.5	01	--	.5	--	--	.5	05
Bryum pseudotriquetrum	--	.5	--	--	--	.5	--	.5	--	--
Cetraria ericetorum	--	.5	.5	--	--	--	.5	--	--	--
Cetraria nivalis	--	.5	.5	--	--	--	02	--	--	--
Cladonia spp.	.5	.5	.5	.5	.5	06	10	.5	15	10
Dactylina arctica	--	.5	--	02	--	--	--	--	--	--
Dicranum acutifolium	01	--	01	02	--	--	.5	--	--	--
Dicranum scoparium	--	05	.5	01	--	03	30	05	.5	--
Drepanocladus uncinatus	.5	.5	--	01	--	.5	.5	10	--	10
Hylocomium splendens	95	90	10	65	70	50	30	30	25	40
Nephroma expallidum	01	.5	02	03	03	03	--	--	--	.5
Peltigera aphthosa	--	01	03	08	07	06	03	20	05	10
Peltigera canina	.5	.5	.5	.5	--	--	.5	.5	--	.5
Pleurozium schreberi	01	--	06	--	.5	10	--	10	45	20
Psoroma hypnorum	--	.5	.5	--	--	--	.5	.5	--	.5
Tomenthypnum nitens	--	.5	--	--	--	--	.5	05	--	--
EPIPHYTES										
Bryoria lanestris	--	--	--	.5	--	.5	--	--	--	.5
Bryoria glabra	.5	.5	.5	--	--	--	--	.5	--	--
Cetraria pinastri	.5	--	--	.5	--	--	.5	.5	--	--
Hypogymnia austerodes	--	.5	--	.5	.5	.5	--	.5	--	--
Letharia vulpina	.5	--	.5	.5	--	--	--	.5	--	.5
Parmeliopsis ambigua	.5	--	.5	.5	.5	.5	--	.5	--	--
Parmeliopsis hyperopta	--	--	.5	.5	.5	--	--	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Other Studies: No similar type has been described.

C26: ***Picea glauca/Shepherdia canadensis/ Thuidium abietinum***

(white spruce/buffaloberry/fern moss)

Environment: The C26 v.t. occurs on mesic, Montane to Lower Subalpine sites (1000-1600 m) of various slopes and usually northerly aspect in the east gate area of Jasper and the Saskatchewan Crossing area of Banff. The soils are generally well drained Cumulic Regosols on eolian and fluvial landforms.

C26 is restricted to areas where active deposition of calcareous loess is occurring.

Vegetation: *Picea glauca* (25-30%) is the dominant tree (Table 33). The shrub layer has a total cover >10%, often around 30%, and *Shepherdia canadensis* (>10%) is dominant (Plate 27). *Rosa acicularis* is often present but with cover <5%. *Juniperus communis* is also frequently present. The herb-dwarf shrub layer is dominated by *Elymus innovatus* (5-20%), *Linnaea borealis* (5-20%), and *Arctostaphylos uva-ursi* (3-15%). *Carex concinna* and *Pyrola secunda* occur with high frequency but with cover <3%. *Thuidium abietinum* (>50%) dominates the bryoid layer. *Peltigera aphthosa* and *Peltigera canina* occur with low cover, but species richness is low in this layer. Epiphytes are sparse to absent.

Table 33 Stands representing the white spruce / buffaloberry / fern moss (C26) v.t.

	AW	IC	JC	JE	JE	PA	PA	SJ	SJ	SJ
	71	51	70	90	90	70	70	70	70	70
	04	08	14	17	18	49	50	09	20	21
TREE LAYER										
Picea glauca	35	30	40	05	25	30	30	27	29	35
Populus tremuloides	--	.5	--	--	--	--	--	22	--	.5
TALL SHRUB LAYER										
Picea glauca	.5	--	06	01	15	.5	05	10	15	07
SHRUB LAYER										
Juniperus communis-	22	.5	--	02	05	25	30	01	--	--
Rosa acicularis	--	01	04	02	04	--	--	06	02	04
Shepherdia canadensis	35	20	06	20	06	35	20	25	25	25
HERB-DWARF SHRUB LAYER										
Arctostaphylos uva-ursi	--	20	03	02	.5	15	02	02	--	--
Aster conspicuus	--	--	03	.5	01	--	--	--	07	06
Carex concinna	02	02	.5	01	05	.5	--	--	--	--
Carex eburnea	--	.5	--	.5	--	--	--	--	.5	01
Elymus innovatus	06	--	15	40	37	15	11	30	05	02
Fragaria virginiana	--	--	.5	--	--	--	--	01	04	04
Geocaulon lividum	--	--	.5	--	--	08	03	03	02	05
Linnaea borealis	38	.5	.5	--	10	.5	20	10	05	03
Pyrola secunda	01	.5	.5	--	--	.5	01	.5	03	.5
BRYOID LAYER										
Distichium capillaceum	--	--	04	--	.5	--	.5	--	.5	--
Ditrichum flexicaule	--	--	02	.5	.5	--	02	--	.5	--
Peltigera aphthosa	02	--	--	--	--	.5	05	--	--	--
Peltigera canina	--	--	.5	--	--	--	--	.5	.5	.5
Thuidium abietinum	58	60	12	50	60	70	55	02	50	55

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Successionally, C26 is mature with most stands 100 to 200 years old. Several stands which are 50 to 75 years old indicate that the C26 composition is established soon after fire.

The C27 v.t. differs from C26 by occurring only in Jasper and by having *Rosa acicularis* dominant in the shrub layer (Table 10). The C37 v.t. differs from C26 by having a bryoid layer dominated by *Hylocomium splendens* rather than *Thuidium abietinum*, although both types have a *Shepherdia canadensis* dominated shrub layer. The C2 v.t. has a shrub layer with <5% cover and a sparse herb-dwarf shrub layer, in contrast to the higher cover of these layers in C26.

Other Studies: Descriptions of similar types by other authors were not found.

C27: *Picea glauca/Rosa acicularis/Thuidium abietinum*

(white spruce/prickly rose/fern moss)

Environment: The C27 v.t. occurs on mesic, Montane sites (1000-1300 m) on nearly level to moderate slopes of northerly aspect mostly in the Athabasca River valley near the east gate of Jasper. The soils are Regosols on eolian and fluvial landforms. Deposition of calcareous loess is occurring on these sites.

Table 34 Stands representing the white spruce / prickly rose / fern moss (C27) v.t.

	IC	IC	IC	IC	JC	JN	SJ	SJ	SJ
	70	70	80	80	70	80	70	70	70
	03	04	01	02	12	01	01	02	16
TREE LAYER									
Betula papyrifera	03	--	04	--	--	--	--	--	--
Picea glauca	32	30	35	22	33	27	31	40	35
Pinus contorta	--	--	--	--	15	--	--	--	.5
TALL SHRUB LAYER									
Betula occidentalis	01	--	.5	05	--	--	--	--	--
Picea glauca	--	01	02	05	02	05	--	11	10
SHRUB LAYER									
Amelanchier alnifolia	01	.5	--	03	--	01	--	03	--
Betula papyrifera	--	--	.5	--	--	--	--	--	--
Cornus stolonifera	04	--	--	02	--	--	.5	--	.5
Juniperus communis	05	--	30	--	01	--	--	--	04
Lonicera dioica	.5	.5	01	01	--	01	03	05	--
Picea glauca	--	02	02	01	01	01	--	--	--
Prunus virginiana	07	--	--	--	--	--	--	03	--
Rosa acicularis	30	15	10	10	04	22	15	08	05
Shepherdia canadensis	--	01	.5	.5	26	05	--	04	07
Viburnum edule	02	--	.5	01	--	--	--	--	--
HERB-DWARF SHRUB LAYER									
Anemone multifida	--	.5	--	--	--	--	--	.5	--
Arctostaphylos uva-ursi	--	01	.5	--	03	01	--	07	05
Aquilegia jonesii	--	.5	--	--	--	01	.5	--	--
Aster ciliolatus	--	01	--	--	.5	.5	--	--	.5
Carex concinna	--	08	05	05	--	05	--	--	--
Carex eburnea	03	05	05	10	--	02	--	03	--
Carex richardsonii	--	.5	.5	01	--	.5	--	--	--
Cypripedium calceolus	--	.5	--	--	--	.5	--	--	.5	--
Elymus innovatus	10	20	30	10	07	23	20	04	07
Fragaria virginiana	--	01	.5	--	02	.5	.5	.5	03
Gallum boreale	--	.5	--	--	--	.5	01	.5	--
Geocaulon lividum	--	--	01	.5	--	01	03	.5	01
Hedysarum alpinum	.5	--	--	01	--	--	04	.5	01
Hedysarum mackenzii	--	03	01	--	--	01	--	.5	--
Linnaea borealis	03	--	02	.5	12	03	20	08	03
Pyrola asarifolia	--	--	--	.5	.5	.5	--	--	--
Pyrola secunda	--	--	.5	--	.5	02	--	.5	.5
Pyrola virens	--	--	.5	.5	--	--	--	--	--
Rubus pubescens	01	--	--	01	--	.5	--	--	--
Smilacina stellata	.5	--	--	.5	--	.5	.5	.5	--
Solidago decumbens	--	01	--	.5	.5	--	--	--	--
Viola adunca	--	.5	--	--	--	.5	--	.5	--
Zygadenus elegans	--	.5	.5	.5	.5	.5	--	.5	--
BRYOID LAYER									
Brachythecium spp.	01	.5	.5	--	--	.5	.5	.5	--
Campylium chrysophyllum	--	--	--	01	--	--	--	--	.5
Distichium capillaceum	--	--	--	01	--	--	--	--	.5
Hylocomium splendens	--	--	--	--	--	--	--	--	18
Peltigera canina	--	--	.5	--	--	.5	.5	--	.5
Pylaisiella polyantha	--	--	.5	--	--	02	--	--	--
Thuidium abietinum	--	01	15	01	--	07	30	.5	50
Tortula ruralis	--	--	.5	--	--	02	--	.5	05

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: The dominant tree is *Picea glauca*

(25-35%) (Table 34, Plate 28). The shrub layer has a total cover of 20 to 40% dominated by *Rosa acicularis* (10-20%). *Shepherdia canadensis* and *Lonicera dioica* occur frequently but with cover <5% usually. The herb-dwarf shrub layer has 30 to 40% cover and is dominated by *Elymus innovatus* (10-20%), *Linnaea borealis* (2-12%), and *Carex eburnea* (5-10%). *Geocaulon lividum*, *Zygadenus elegans*, *Smilacina stellata*, and *Fragaria virginiana* occur frequently but with low cover. *Thuidium abietinum* dominates the sparse bryoid layer. Terrestrial and epiphytic lichens are scarce to absent.

The C27 v.t. is mature successionally with most stands 120 to 150 years old.

The C27 v.t. differs from C26 by having the shrub layer dominated by *Rosa acicularis* rather than *Shepherdia canadensis*, and from C37 by the bryoid layer being dominated by *Thuidium abietinum* rather than *Hylocomium splendens* (Table 10). The C2 v.t. differs in having a shrub layer with <5% cover and a sparse herb-dwarf shrub layer.

Other Studies: The "upland white spruce forest" type of Kuchar (1972) in Jasper is similar to C27.

C28: *Populus balsamifera/Equisetum pratense*

(balsam poplar/horsetail)

Environment: The C28 v.t. occurs on hygric to subhygric, Montane (1000-1100 m) sites of gentle slope (<5%) on various aspects in Jasper. The soils are imperfectly to well drained Regosols developed on fluvial landforms in broad valleys where wetter soils are prevalent.

Vegetation: *Populus balsamifera* is the dominant canopy tree with 35 to 55% cover and *Picea glauca* may be present in small amounts (Table 35). Shrub cover is low (<15%) with *Rosa acicularis* (2%) and *Viburnum edule* (<5%) predominating. The herb-dwarf shrub layer has high cover (55-80%) and is dominated by *Equisetum pratense* (<60%), *Equisetum arvense* (<20%), and *Mertensia paniculata* (<15%). Other characteristic species include *Rubus pubescens* (<5%), *Petasites palmatus* (<2%), *Vicia americana* (1%), and *Galium triflorum* (<1%). The bryoid layer has very low coverage (1%) with traces of *Brachythecium salebrosum*, *Bryum caespiticium*, and *Mnium cuspidatum*. Successionally, C28 is intermediate with trees less than 100 years, and eventual succession to C32 appears likely when the site becomes geomorphically stable and is no longer susceptable to periodic flooding.

The C28 v.t. is distinguished from C16 by the dominance of *Populus balsamifera* rather than *Populus tremuloides* and by wetter soils on more gentle slopes. The C17 v.t. occurs on drier (mesic) sites, and has *Shepherdia canadensis* as the dominant shrub and a low cover, if any, of *Equisetum* spp..

Table 35 Stands representing the balsam poplar horsetail (C28) v.t.

	1C 3C 5J 7C 7C 7C 14 01 23
TREE LAYER	
Picea glauca	-- 02 09
Populus balsamifera	55 33 --
Salix scouleriana	-- -- 02
TALL SHRUB LAYER	
Picea glauca	02 -- --
SHRUB LAYER	
Cornus stolonifera	.5 .5 --
Lonicera dioica	01 -- 04
Populus balsamifera	15 -- --
Ribes oxyacanthoides	01 -- --
Ribes triste	01 -- --
Rosa acicularis	02 02 02
Symphoricarpos albus	-- 08 --
Viburnum edule	06 -- --
HERB-DWARF SHRUB LAYER	
Achillea millefolium	-- -- 04
Actaea rubra	01 -- --
Agrostis spp.	-- -- 03
Aster ciliolatus	01 -- --
Elymus innovatus	-- 02 08
Equisetum arvense	01 20 15
Equisetum pratense	60 15 --
Galium triflorum	.5 .5 --
Hedysarum alpinum	-- -- 05
Heracleum lanatum	-- .5 15
Lathyrus ochroleucus	-- 04 --
Lilium philadelphicum	-- .5 --
Mertensia paniculata	01 15 --
Mitella nuda	01 -- .5
Petasites palmatus	02 01 --
Rubus pubescens	05 01 --
Smilacina racemosa	01 -- --
Taraxacum officinale	.5 -- 15
Vicia americana	01 01 08
BRYOID LAYER	
Amblystegium serpens	.5 -- --
Brachythecium salebrosum	.5 -- --
Bryum caespiticium	-- .5 --
Mnium cuspidatum	.5 -- --
Mnium rugicum	-- -- .5
Scapania spp.	-- .5 --
EPIPHYTES	
Usnea subfloridana	.5 -- --

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Other Studies: Descriptions of similar types by other authors were not found.

C29: *Pinus contorta/Ledum groenlandicum*

(lodgepole pine/Labrador tea)

Environment: The C29 v.t. occurs on mesic, Montane to Lower Subalpine sites (1400-1850

m) on various slopes of northerly aspect. The soils are well drained Eutric Brunisols, Brunisolic Gray Luvisols, and Dystric Brunisols on eolian, morainal, and fluvial landforms.

Table 36 Stands representing the lodgepole pine / Labrador tea (C29) v.t.

	AW	IC	IC	JD	JW	KE	PA	PA	PA	SJ
	90	70	80	90	80	90	81	90	91	80
	90	95	61	81	76	76	68	91	87	76
TREE LAYER										
Picea engelmannii	05	.5	5	02	--	--	.5	05	.5	03
Pinus contorta	33	39	30	33	30	39	40	45	49	33
TALL SHRUB LAYER										
Abies lasiocarpa	--	--	01	--	--	--	--	--	--	--
Picea engelmannii	03	--	--	01	.5	.5	10	03	.5	--
Picea mariana	--	.5	02	--	--	--	--	--	--	--
Pinus contorta	--	--	--	02	01	--	.5	02	--	--
SHRUB LAYER										
Abies lasiocarpa	02	--	01	--	.5	01	.5	15	--	--
Juniperus communis	--	--	--	01	01	.5	--	--	--	--
Ledum glandulosum	--	--	--	--	--	--	20	--	--	--
Ledum groenlandicum	16	40	32	30	40	30	--	30	30	32
Menziesia glabella	12	--	--	--	02	03	--	--	--	--
Picea engelmannii	01	--	--	.5	.5	05	--	.5	--	07
Salix glauca	--	--	--	05	.5	--	05	--	--	07
Shepherdia canadensis	01	--	.5	01	02	--	--	--	05	03
HERB-DWARF SHRUB LAYER										
Arnica cordifolia	02	--	.5	--	05	--	.5	.5	01	27
Cornus canadensis	03	--	01	01	07	03	--	15	05	--
Elymus innovatus	01	02	.5	40	04	.5	.5	.5	--	07
Empetrum nigrum	--	--	.5	.5	--	--	--	--	10	--
Epilobium angustifolium	.5	.5	--	.5	--	--	.5	.5	.5	--
Pyrola secunda	.5	--	--	--	--	--	--	.5	.5	01
Linnaea borealis	17	--	06	05	06	03	--	05	05	--
Vaccinium caespitosum	--	--	--	20	01	--	--	--	--	--
Vaccinium scoparium	11	03	--	--	--	10	20	--	--	--
Vaccinium vitis-idaea	.5	01	04	02	07	--	--	10	.5	08
Equisetum scirpoides	.5	.5	.5	--	01	--	--	--	--	--
Lycopodium annotinum	04	02	--	.5	--	--	10	10	05	01
BRYOID LAYER										
Cladonia arbuscula	--	--	--	.5	--	--	--	05	--	--
Cladonia mitis	--	01	--	.5	.5	--	--	--	--	--
Cladonia conotea	--	--	--	--	.5	--	--	--	--	.5
Cladonia coccifera	--	--	--	--	.5	--	--	--	--	.5
Cladonia crispata	--	--	--	.5	--	--	--	--	--	.5
Cladonia deformis	--	--	--	.5	--	--	.5	--	--	--
Cladonia gonecha	--	--	--	--	.5	--	--	--	--	.5
Dicranum scoparium	--	--	--	--	--	01	.5	--	--	02
Hylocomium splendens	06	05	30	10	70	10	--	35	15	20
Peltigera aphthosa	10	.5	02	--	01	05	25	10	09	02
Pleurozium schreberi	70	60	45	60	15	80	30	40	60	15
Polytrichum juniperinum	01	--	--	--	.5	--	10	--	--	.5
Ptilium crista-castrensis	03	02	05	--	05	--	--	.5	20	12
Stereocaulon tomentosum	--	--	--	.5	--	--	--	--	--	.5
EPIPHYTES										
Bryoria fuscescens	--	--	--	.5	--	--	--	.5	--	.5
Cetraria pinastri	--	--	--	--	.5	--	--	--	--	.5
Hypogymnia austerodes	--	--	--	--	--	--	--	.5	--	.5
Hypogymnia physodes	--	--	--	--	.5	--	--	--	--	.5
Letharia vulpina	--	--	--	--	--	--	--	--	.5	.5
Parmelia sulcata	--	--	--	--	.5	--	--	.5	--	--
Parmeliopsis ambigua	--	--	--	--	.5	--	--	--	--	.5
Usnea sorediifera	--	--	--	.5	.5	--	--	--	--	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: *Pinus contorta* (20-45%) dominates the closed tree layer (Plate 29), with *Picea engelmannii* or *Picea engelmannii* x *Picea glauca* common (≤10%) (Table 36). The shrub layer has a total cover of 25 to 50% with *Ledum groenlandicum* (10-40%) dominant. *Shepherdia canadensis* (1-5%), *Salix glauca* (1-5%), and *Juniperus communis* (1-3%) are often also present. The herb-dwarf shrub layer has moderate to dense cover (25-50%) and commonly contains *Vaccinium scoparium* (5-15%), *Linnaea borealis* (3-5%), *Vaccinium vitis-idaea* (3-5%), *Elymus innovatus* (1-5%), *Arnica cordifolia* (1-5%), and *Cornus canadensis* (1-5%). The dense bryoid layer (40-80%) is dominated by *Pleurozium schreberi* (35-45%), *Hylocomium splendens* (20-35%), *Ptilium crista-castrensis* (5-15%), and *Peltigera aphthosa* (1-3%). Common epiphytes include *Letharia vulpina*, *Cetraria pinastri*, *Usnea sorediifera*, and *Parmeliopsis ambigua*.

The C29 v.t. is intermediate to advanced successionally with most stands 75 to 200 years old. The presence of *Picea engelmannii* and *Abies lasiocarpa* in lower layers indicates succession to C30 as a mature stage.

The C29 v.t. is distinguished from C30 by having *Pinus contorta* dominant in the tree layer rather than *Picea engelmannii*.

Other Studies: Similar types have been described in Alberta by Ogilvie (1976, seral *Pinus contorta* dominated stands of the *Picea-Abies/Ledum-Empetrum* type), La Roi (1975) in Jasper (*Pinus contorta/Ledum groenlandicum/Vaccinium scoparium/Linnaea borealis/Hylocomium splendens*), by Corns (1978) in the northern foothills of Alberta (*Pinus contorta/Ledum groenlandicum/Pleurozium schreberi*), and by La Roi and Hnatiuk (1980) in Banff and Jasper (*Pinus contorta/Ledum groenlandicum/Vaccinium scoparium*).

C30: *Picea engelmannii-Abies lasiocarpa/Ledum groenlandicum/Empetrum nigrum*

(Engelmann spruce-subalpine fir/Labrador tea/crowberry)

Environment: The C30 v.t. occurs on mesic, Lower Subalpine sites (1540-2000 m) on gentle to moderate slopes of usually northerly and easterly aspect. The soils are well drained Eutric and Dystric Brunisols on eolian and morainal landforms.

Vegetation: The closed tree layer (Plate 30) is dominated by *Picea engelmannii* (20-40%) with lesser amounts of *Abies lasiocarpa* (5-10%) and *Pinus contorta* (<5%) (Table 37). The shrub layer has moderately dense cover (30-50%) and is dominated by *Ledum groenlandicum* (10-30%), with *Abies lasiocarpa* (3-10%), *Picea engelmannii* (3-5%), and *Salix glauca* (1-3%). *Empetrum nigrum* (8-20%) dominates the herb-dwarf shrub layer. Other common species are: *Vaccinium vitis-idaea* (3-5%), *Elymus innovatus* (5%), *Vaccinium scoparium* (5-10%), *Arnica cordifolia* (1-3%), and *Cornus canadensis* (1-3%). The dense bryoid layer (50-80%) contains *Hylocomium splendens* (30-50%), *Pleurozium schreberi* (15-35%), *Ptilium crista-castrensis* (5-15%), and *Peltigera aphthosa* (1-3%). Common epiphytes include *Letharia vulpina*, *Cetraria pinastri*, and *Parmeliopsis ambigua*.

Table 37 Stands representing the Engelmann spruce-subalpine fir / Labrador tea / crowberry (C30) v.t.

	AW	IC	JC	JD	JD	JE	LC	PA	SJ	SJ
	70	61	69	60	70	80	91	90	70	80
	70	15	87	61	92	74	52	69	44	11
TREE LAYER										
Abies lasiocarpa	05	--	37	63	--	05	--	.5	.5	03
Picea engelmannii	17	21	21	25	27	20	15	30	25	16
Pinus albicaulis	01	--	--	--	--	--	--	--	--	--
Pinus contorta	.5	09	--	02	05	--	10	10	05	10
TALL SHRUB LAYER										
Abies lasiocarpa	02	--	04	--	--	01	10	--	.5	--
Picea engelmannii	02	03	01	01	02	01	--	05	08	03
Pinus contorta	--	--	--	--	03	--	05	.5	--	03
SHRUB LAYER										
Abies lasiocarpa	03	--	15	03	--	02	06	--	--	03
Juniperus communis	--	02	--	--	--	--	03	--	03	--
Ledum groenlandicum	18	30	33	45	30	01	13	10	11	30
Picea engelmannii	02	--	02	.5	01	.5	--	03	--	03
Salix glauca	01	01	--	.5	05	--	--	.5	.5	04
HERB-DWARF SHRUB LAYER										
Arnica cordifolia	--	.5	.5	.5	.5	.5	--	10	03	--
Cornus canadensis	--	06	01	01	--	--	05	05	--	.5
Elymus innovatus	--	15	--	.5	08	--	--	05	03	.5
Empetrum nigrum	30	02	01	10	35	14	20	15	05	18
Linnaea borealis	--	04	01	--	03	.5	09	15	05	--
Pedicularis bracteosa	--	.5	--	--	.5	--	--	--	--	--
Pyrola secunda	--	--	01	--	.5	--	--	.5	--	--
Vaccinium scoparium	01	08	01	05	05	11	--	--	05	--
Vaccinium vitis-idaea	--	01	--	03	05	--	05	.5	05	10
Lycopodium annotinum	02	.5	--	.5	--	--	--	05	--	--
BRYOID LAYER										
Cladonia arbuscula	--	--	--	--	.5	.5	09	--	--	--
Cladonia mitis	--	--	--	--	--	--	--	--	03	04
Cladonia ecmocyna	--	--	--	.5	02	02	02	.5	.5	--
Cladonia gonecha	--	--	--	--	.5	--	.5	01	--	.5	--
Dicranum scoparium	--	--	--	--	--	--	--	10	05	--	03
Hylocomium splendens	80	30	82	60	25	15	--	30	01	23
Peltigera aphthosa	--	02	02	.5	.5	03	05	05	04	06
Pleurozium schreberi	10	20	06	30	35	15	40	35	30	04
Polytrichum juniperinum	--	--	--	--	--	--	.5	20	--	.5	01
Ptilium crista-castrensis	--	15	06	05	.5	--	--	05	02	--
Dicranum brevifolium	--	--	--	--	--	.5	03	--	--	.5
EPIPHYTES										
Alectoria spp.	--	--	.5	.5	.5	--	--	--	--	--
Bryoria fremontii	--	--	--	--	--	.5	.5	.5	--	--
Bryoria fuscescens	--	--	--	--	--	--	--	--	.5	--	.5
Cetraria pinastri	--	--	--	--	--	.5	--	--	.5	.5
Letharia vulpina	--	--	--	.5	.5	.5	.5	.5	.5	.5
Parmelia sulcata	--	--	--	--	--	--	--	.5	.5	.5
Parmeliopsis ambigua	--	--	--	--	--	.5	--	.5	.5	.5
Parmeliopsis hyperopta	--	--	--	--	--	.5	--	--	.5	.5
Usnea scrediifera	--	--	--	--	--	--	--	.5	.5	--
Usnea subfloridana	--	--	--	--	--	--	.5	.5	--	--
Usnea spp.	--	--	.5	.5	.5	--	--	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The C30 v.t. is mature successionally with stands typically 200 to 400 years old. *Picea engelmannii* and *Abies lasiocarpa* regeneration is common in the lower layers.

The C30 v.t. is distinguished from C29 by having dominance of *Picea engelmannii* in the tree layer and the usual dominance of *Empetrum nigrum* in the herb-dwarf shrub layer.

Other Studies: Similar types were described for Alberta by La Roi (1975) for Jasper (*Picea engelmannii/Abies lasiocarpa/Ledum groenlandicum/Vaccinium scoparium/Hylocomium splendens*), Ogilvie (1963) for Banff (*Picea-Abies/Ledum groenlandicum*), and Trottier and Scotter (1973) for Banff (*Picea-Abies/Ledum groenlandicum-Empetrum nigrum*).

C31: *Picea engelmannii-Abies lasiocarpa/Elymus innovatus-Arnica cordifolia-Linnaea borealis/Hylocomium splendens*

(Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss)

Environment: The C31 v.t. occurs on mesic, Lower Subalpine (1700-1975 m) sites of moderate slope on various aspects, mostly in the Front Ranges of eastern Banff and Jasper. The soils are generally well drained Eutric Brunisols developed on fluvial and glacial landforms.

Table 38 Stands representing the Engelmann spruce-subalpine fir / hairy wild rye-heartleaf arnica-twinflower / feathermoss (C31) v.t.

	AW	IC	JD	JD	JE	JW	PA	PA	PA	SJ
	60	80	80	80	90	80	80	80	90	70
	52	26	40	43	92	40	41	45	31	11
TREE LAYER										
Abies lasiocarpa	01	--	--	--	10	.5	--	--	--	17
Picea engelmannii	36	25	45	40	30	41	40	35	35	20
Pinus contorta	.5	--	--	--	05	03	.5	05	--	01
TALL SHRUB LAYER										
Picea engelmannii	.5	02	.5	.5	02	02	03	02	.5	03
SHRUB LAYER										
Abies lasiocarpa	05	--	--	--	02	01	--	5-	--	--
Picea engelmannii	01	01	.5	.5	01	--	05	--	.5	06
Shepherdia canadensis	.5	--	.5	.5	--	--	--	03	--	--
HERB-DWARF SHRUB LAYER										
Achillea millefolium	--	.5	.5	.5	--	--	--	--	--	--
Arnica cordifolia	01	04	15	03	15	03	01	10	.5	05
Carex concinna	02	.5	.5	.5	--	--	.5	--	--	--
Cornus canadensis	02	--	--	--	03	--	--	--	.5	.5
Delphinium glaucum	--	.5	--	--	--	--	--	.5	03	--
Elymus innovatus	09	09	10	15	15	02	05	05	20	04
Epilobium angustifolium	.5	01	.5	.5	02	--	--	.5	02	.5
Fragaria virginiana	01	.5	02	.5	.5	--	--	--	--	--
Linnaea borealis	03	05	.5	.5	10	02	10	05	.5	01
Hedysarum sulphurescens	--	--	.5	02	--	--	.5	--	--	--
Moneses uniflora	--	--	.5	.5	--	.5	--	--	--	--
Pyrola secunda	.5	.5	--	.5	.5	.5	--	.5	.5	--
Senecio lugens	.5	--	.5	.5	--	--	.5	--	--	--
Equisetum scirpoides	--	.5	--	--	--	--	--	--	.5	.5
BRYOID LAYER										
Cladonia gonecha	--	--	--	--	.5	.5	--	--	--	--
Cladonia pyxidata	--	--	--	--	--	.5	--	--	--	.5
Cladonia spp.	12	--	--	--	--	02	.5	--	--	--
Dicranum brevifolium	--	01	--	02	.5	.5	--	--	--	--
Dicranum muehlenbeckii	--	--	--	01	--	05	--	--	--	--
Drepanocladus uncinatus	--	04	30	10	--	--	--	--	--	.5
Hylocomium splendens	40	50	40	60	30	40	40	30	45	60
Peltigera aphthosa	15	12	01	05	.5	09	10	05	05	.5
Pleurozium schreberi	22	10	--	--	30	30	20	25	30	--
Pohlia nutans	--	--	--	--	.5	.5	--	--	--	.5
Polytrichum juniperinum	.5	.5	--	--	--	.5	--	--	--	--
Ptilium crista-castrensis	--	--	--	--	.5	01	.5	20	.5	01
EPIPHYTES										
Bryoria glabra	--	.5	.5	.5	--	--	--	--	--	.5
Cetraria pinastri	--	--	--	--	.5	.5	--	--	--	.5
Hypogymnia austerodes	--	.5	.5	--	--	.5	--	--	--	.5
Hypogymnia physodes	--	--	.5	--	.5	.5	--	--	.5	.5
Letharia vulpina	--	--	.5	.5	.5	--	--	--	--	--
Parmelia exasperatula	--	--	.5	--	--	.5	--	--	--	.5
Parmelia sulcata	--	.5	--	--	.5	.5	--	--	--	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: *Picea engelmannii* is the dominant canopy tree (Plate 31) with 30 to 45% cover (Table 38). *Abies lasiocarpa* is usually present but with much lower cover (1-5%). *Pinus contorta* may also be present (<5%). The shrub layer has <5% cover with *She-*

pherdia canadensis and *Juniperus communis* as common dominants. Herb-dwarf shrub layer cover is >15%. Dominant species are *Elymus innovatus* (5-10%), *Linnaea borealis* (5-15%), and *Arnica cordifolia* (5-10%). *Vaccinium scoparium* is often present with 5 to 15% cover. The bryoid layer is dominated by *Hylocomium splendens* (20-50%) and *Pleurozium schreberi* (20-30%) and has a total cover of 40 to 75%. *Peltigera aphthosa* is nearly always present with <10% cover. Epiphytic lichens are in moderate abundance with *Usnea sorediifera* and *Alectoria glabra* most common.

Successionally, C31 is predominantly mature with most stands 200 to 300 years old. Earlier successional stages are similar to C19.

The C31 v.t. is distinguished from C13 by having a herb-dwarf shrub cover >15% and a total cover of *Elymus innovatus* plus *Arnica cordifolia* plus *Linnaea borealis* >10%. *Vaccinium scoparium* is often present in C31 with >5% cover while in C13 it is usually absent. The C33 v.t. differs from C31 in having <25% cover of feathermosses (*Hylocomium splendens, Pleurozium schreberi, Ptilium crista-castrensis*) and by occurrences usually at elevations >2000 m. Intergrades to C13 and C33 occur.

Other Studies: In Banff, Trottier and Scotter (1973) have described a *Picea-Abies/Shepherdia canadensis* type which is similar to C31. In Jasper, Hettinger (1975) has described a similar *Picea glauca/Elymus innovatus-Cornus canadensis* type, while in the Porcupine Hills, Duffy (1971) and Ogilvie (1971) have described similar herb-rich white spruce forests. Pfister et al. (1977) have described a similar *Abies lasiocarpa/Arnica cordifolia* type in Montana.

C32: *Picea engelmannii/Equisetum arvense/Hylocomium splendens*

(Engelmann spruce/horsetail/feathermoss)

Environment: The C32 v.t. occurs on mesic to subhygric sites mostly in the Lower Subalpine (usually <1500 m in Jasper; 1460-1870 m in Banff) on gentle to moderate slopes on various aspects in eastern Banff and Jasper. The soils are Regosols and Rego Gleysols on fluvial landforms.

Vegetation: *Picea engelmannii* (with *P. engelmannii* x *P. glauca* hybrids at lower elevations) is the dominant canopy tree with 20 to 40% cover (Table 39). The shrub layer is generally sparse with <15% cover contributed mostly by tree regeneration. Herb-dwarf shrub cover is 35 to 70% with *Equisetum arvense* (20-50%) dominant (Plate 32). Also common are *Arnica cordifolia* (3-5%), *Elymus innovatus* (<5%), *Linnaea borealis* (5%), *Mertensia paniculata* (≤1%), and *Mitella nuda* (≤1%). Bryoid cover is 50 to 80%, *Hylocomium splendens* (25-50%) is dominant, followed by *Pleurozium schreberi* (10%), *Ptilium crista-castrensis* (5%), and *Peltigera aphthosa* (3%).

Table 39 Stands representing the Engelmann spruce / horsetail / feathermoss (C32) v.t.

	IC 80 59	JR 81 33	JN 80 17	JH 80 60	RS 61 00	LC 90 10	LC 91 46	PA 90 51	PA 90 83	PA 90 94
TREE LAYER										
Abies lasiocarpa	03	14	--	--	--	--	--	--	--	.5
Picea engelmannii	21	21	30	34	80	35	35	80	40	80
Populus balsamifera	--	--	--	--	--	05	--	--	--	--
TALL SHRUB LAYER										
Abies lasiocarpa	02	01	--	--	--	--	--	02	.5	.5
Picea engelmannii	.5	02	--	01	10	--	05	03	05	.5
SHRUB LAYER										
Abies lasiocarpa	02	01	--	--	.5	--	03	05	05	--
Picea engelmannii	--	01	03	01	02	--	05	.5	.5	--
Salix glauca	.5	05	--	.5	02	--	--	--	--	--
HERB-DWARF SHRUB LAYER										
Arnica cordifolia	03	--	--	05	06	--	03	--	05	05
Cornus canadensis	05	02	--	--	03	01	02	--	--	15
Elymus innovatus	03	.5	--	.5	--	04	03	--	--	--
Epilobium angustifolium	--	--	01	.5	.5	--	02	--	.5	--
Equisetum arvense	10	10	02	05	--	06	20	40	50	60
Equisetum pratense	--	05	--	--	50	--	--	--	--	--
Equisetum scirpoides	.5	01	01	--	.5	03	.5	01	--	.5
Linnaea borealis	04	01	10	--	03	05	15	--	--	--
Mertensia paniculata	.5	--	--	01	--	01	01	--	--	--
Mitella nuda	--	.5	--	01	04	--	.5	03	--	03
Petasites palmatus	01	.5	--	05	--	--	.5	--	--	--
Petasites vitifolius	--	01	03	--	--	--	--	--	05	.5
Pyrola secunda	01	.5	01	.5	02	01	.5	.5	--	--
Thalictrum occidentale	--	--	--	--	10	--	--	--	05	10
BRYOID LAYER										
Aulacomnium palustre	.5	01	--	01	10	--	--	10	--	--
Barbilophozia lycopodioides	--	4-	--	.5	10	--	--	05	--	--
Drepanocladus uncinatus	--	.5	.5	--	55	03	--	.5	--	--
Hylocomium splendens	65	35	75	75	--	75	40	40	40	10
Peltigera aphthosa	.5	.5	--	.5	--	--	08	15	10	.5
Peltigera canina	--	.5	.5	01	--	--	--	05	--	--
Pleurozium schreberi	15	30	.5	01	05	--	10	05	20	60
Ptilium crista-castrensis	10	02	05	01	--	--	10	--	--	--
EPIPHYTES										
Bryoria fremontii	--	.5	--	--	--	--	--	.5	.5	.5
Bryoria pseudofuscescens	--	--	--	.5	--	--	--	.5	.5	--
Letharia vulpina	--	.5	--	--	--	--	--	.5	.5	--
Parmelia sulcata	--	.5	--	.5	--	--	--	.5	--	.5
Parmeliopsis ambigua	--	.5	--	.5	--	--	--	--	.5	.5
Usnea alpina	--	--	--	.5	--	.5	--	.5	--	--
Usnea sorediifera	.5	--	--	--	--	--	--	.5	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Successionally, C32 is mature with stand ages of 200 to 400 years. *Picea engelmannii* regeneration is common in the shrub layer.

The C32 v.t. is similar to C4 but generally occurs on drier, Lower Subalpine (>1500 m) sites with a sparse shrub layer in which *Rosa acicularis, Cornus stolonifera,* and *Alnus tenuifolia* are usually absent, and with *Arnica cordifolia, Elymus innovatus,* and *Mertensia paniculata* in the herb-dwarf shrub layer.

Other Studies: Similar types have been described for Alberta by Corns (1978) for the northwestern foothills (*Picea glauca/Equisetum arvense/Hylocomium splendens*), Mackenzie-Grieve (1970) for the Red Deer

River area east of Banff (*Populus-Pinus/Heracleum-Delphinium-Aster-Equisetum*), Kirby and Ogilvie (1969, *Picea-Abies/Equisetum*), and Jacques and Legge (1974, spruce-fir/horsetail) for the Kananaskis area of Alberta. Trottier and Scotter (1973) described a similar type (*Picea-Abies/Equisetum*) for Banff and Cormack (1953) described similar vegetation for southwestern Alberta as part of his climax spruce-fir forest complex.

C33: *Picea engelmannii/Elymus innovatus*

(Engelmann spruce/hairy wild rye)

Environment: The C33 v.t. occurs on predominantly mesic to subxeric Upper Subalpine (1700-2240m), gently to steeply sloping sites with southerly aspect in eastern Banff. Soils are well drained Eutric Brunisols and Regosols developed on morainal and colluvial landforms.

Vegetation: *Picea engelmannii* (15-50%) is the dominant tree (Table 40, Plate 33). *Pinus contorta* (<10%) occurs in many plots. *Abies lasiocarpa* is usually absent. The shrub layer has low to moderate cover (5-35%) dominated by *Picea engelmannii* regeneration (5-15%), *Juniperus communis* (<5%), and *Shepherdia canadensis* (<5%). The herb-dwarf shrub layer has moderate to high cover (20-85%) and is dominated by *Elymus innovatus* (5-40%). Other characteristic species include *Arctostaphylos uva-ursi* (<10%), *Linnuea borealis* (1-10%), *Hedysarum sulphurescens* (<10%), *Arnica cordifolia* (2-10%), *Fragaria virginiana* (<5%), and *Zygadenus elegans* (<5%). The bryoid layer has generally low cover (<30%) with *Hylocomium splendens* (<15%) and *Pleurozium schreberi* (<10%) accounting for most of the cover. *Peltigera aphthosa* (<10%) and *Cladonia* spp. (<5%) are also present. *Letharia vulpina* is common as an epiphyte.

Successionally C33 is mature with stands 100 to 350 years old.

The C33 v.t. is distinguished from C31 by occurring at higher elevations, having <25% feathermoss cover and by generally drier sites.

Other Studies: No similar type has been described by other workers.

C34: *Picea engelmannii-Abies lasiocarpa/Phyllodoce glanduliflora/Hylocomium splendens*

(Engelmann spruce-subalpine fir/heather/feathermoss)

Environment: The C34 v.t. occurs on mesic Upper Subalpine sites (1900-2200 m) on moderate to steep slopes of northerly and easterly aspect. The soils are well to moderately well drained Eutric and Dystric Brunisols and Orthic Humo-Ferric Podzols on morainal landforms.

Table 40 Stands representing the Engelmann spruce / hairy wild rye (C33) v.t.

	IC 91 68	JC 89 21	JC 80 42	JD 90 84	JE 80 96	JE 80 97	PA 80 52	PA 80 99	PA 81 15	PA 81 27
TREE LAYER										
Picea engelmannii	35	30	25	35	30	30	35	25	55	30
Pinus contorta	.5	20	--	--	--	--	--	--	--	20
Abies lasiocarpa	--	--	--	--	--	--	.5	--	.5	.5
TALL SHRUB LAYER										
Abies lasiocarpa	--	--	--	--	--	--	--	--	.5	--
Picea engelmannii	.5	03	02	.5	05	02	03	--	10	10
Pinus contorta	--	02	--	--	--	--	--	--	--	.5
SHRUB LAYER										
Abies lasiocarpa	--	--	--	.5	--	--	02	--	.5	--
Juniperus communis	.5	--	--	.5	--	--	--	--	--	--
Picea engelmannii	.5	01	01	.5	05	.5	01	--	.5	.5
Shepherdia canadensis	.5	02	02	.5	--	.5	--	05	--	25
HERB-DWARF SHRUB LAYER										
Achillea millefolium	01	01	.5	01	--	.5	--	.5	.5	.5
Androsace chamaejasme	--	01	02	.5	--	.5	.5	--	--	--
Antennaria racemosa	02	--	03	--	--	--	02	05	--	01
Arctostaphylos uva-ursi	.5	09	--	02	.5	.5	03	02	.5	03
Arnica cordifolia	03	--	02	--	02	01	--	--	10	25
Campanula rotundifolia	.5	--	--	--	--	--	--	--	--	--
Carex concinna	02	01	01	.5	--	--	--	--	--	--
Castilleja miniata	--	.5	01	--	--	--	.5	--	--	02
Dryas octopetala	--	--	--	--	--	--	03	--	--	--
Elymus innovatus	04	10	10	40	04	04	10	35	15	10
Epilobium angustifolium	.5	--	--	--	.5	--	--	--	.5	--
Erigeron peregrinus	01	--	--	--	--	--	01	.5	--	--
Fragaria virginiana	01	--	.5	--	--	.5	--	.5	.5	02
Hedysarum alpinum	02	--	--	--	--	--	20	--	--	--
Hedysarum sulphurescens	--	10	04	05	--	.5	--	01	01	10
Juniperus communis	--	04	05	--	--	01	10	02	--	05
Linnaea borealis	04	02	10	01	01	09	.5	--	--	35
Pedicularis bracteosa	--	--	02	--	.5	--	15	--	--	--
Pyrola secunda	.5	--	02	--	--	.5	--	--	.5	--
Senecio lugens	--	--	01	--	.5	--	02	--	--	--
Shepherdia canadensis	--	--	--	--	--	--	05	--	--	--
Solidago multiradiata	--	--	01	03	--	.5	--	.5	--	--
Zygadenus elegans	.5	01	01	02	--	.5	05	--	--	.5
BRYOID LAYER										
Brachythecium collinum	--	--	--	--	--	--	--	05	--	--
Brachythecium spp.	--	--	--	01	--	--	02	--	--	--
Bryum spp.	--	.5	--	--	--	--	02	.5	--	--
Cladonia cenotea	--	.5	.5	--	--	--	--	--	.5	--
Cladonia chlorophaea	--	01	--	--	--	.5	.5	--	.5	--
Cladonia ecmocyna	--	--	01	--	.5	--	.5	--	--	--
Cladonia gonecha	.5	--	.5	--	.5	--	--	--	--	--
Cladonia cyxidata	.5	.5	--	01	--	--	--	--	--	--
Cladonia squamosa	--	.5	01	--	--	--	--	--	--	.5
Cladonia spp.	--	02	.5	--	01	02	--	--	--	--
Dicranum scoparium	--	01	--	--	01	--	--	--	05	--
Distichium capillaceum	--	--	--	01	--	--	02	--	--	--
Ditrichum flexicaule	--	--	.5	--	--	--	02	--	--	--
Drepanocladus uncinatus	--	01	.5	.5	01	.5	10	--	05	.5
Drepanocladus spp.	05	--	--	--	--	--	--	--	--	--
Encalypta affinis	--	--	--	--	--	--	03	--	--	--
Eurhynchium pulchellum	--	.5	.5	--	--	--	03	--	--	--
Hylocomium splendens	--	--	01	--	17	15	--	--	10	--
Hypnum revolutum	--	--	--	01	--	.5	--	--	.5	--
Peltigera aphthosa	01	--	--	--	09	01	--	--	10	--
Peltigera canina	01	--	--	.5	01	.5	--	--	.5	.5
Physcia ciliata	--	--	--	--	--	.5	--	--	--	--
Pleurozium schreberi	--	01	01	--	--	.5	--	--	--	--
Pohlia nutans	--	.5	--	--	.5	--	--	--	.5	--
Tortella tortuosa	--	--	.5	--	--	--	02	--	--	--
Tortula ruralis	--	--	--	--	01	.5	--	--	--	--
EPIPHYTES										
Bryoria glabra	--	--	.5	--	.5	--	--	--	.5	--
Hypogymnia austerodes	.5	--	--	.5	.5	.5	--	--	--	--
Letharia vulpina	.5	.5	.5	.5	.5	.5	.5	--	.5	.5
Usnea sorediifera	.5	--	.5	--	.5	--	--	--	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: The tree layer is closed (20-40%) and dominated by *Picea engelmannii* (15-30%) and *Abies lasiocarpa* (5-25%) (Table 41). The shrub layer is moderately dense (10-30%) and composed almost entirely of *Abies lasiocarpa* (10-25%) and *Picea engelmannii* (1-5%) regeneration. The herb-dwarf shrub layer is dense (30-65%) and dominated by *Phyllodoce*

glanduliflora (10-50%) or occasionally *Phyllodoce empetriformis* (Plate 34). Other important dwarf shrubs are *Vaccinium scoparium* (5-15%) and *Cassiope mertensiana* (5-10% in Jasper) or *Cassiope tetragona* (3-5% in Banff). Herb cover is very low. The bryoid layer has a total cover of 40 to 90% and is dominated by *Hylocomium splendens* (10-40%) and *Pleurozium schreberi* (15-45%). Other important species are *Dicranum scoparium* (5-20%), *Drepanocladus uncinatus* (5-10%), *Barbilophozia lycopodioides* (1-5%), *Peltigera aphthosa* (1-5%), and *Cladonia ecmocyna* (1-3%). Epiphytes are in moderate abundance with *Letharia vulpina*, *Parmeliopsis ambigua*, *Parmeliopsis hyperopta*, *Bryoria fremontii*, and *Bryoria glabra* most common.

Table 41 Stands representing the Engelmann spruce-subalpine fir / heather / feathermoss (C34) v.t.

	1C 70 84	JC 60 38	JC 70 51	JD 70 97	KS 60 29	PA 71 46	PA 80 64	PA 80 88	PA 81 16	PA 91 13
TREE LAYER										
Abies lasiocarpa	10	08	25	08	05	25	15	10	05	15
Picea engelmannii	20	32	15	35	45	15	25	25	35	20
TALL SHRUB LAYER										
Abies lasiocarpa	08	04	10	20	02	10	10	15	15	02
Picea engelmannii	02	01	--	--	15	.5	10	10	05	01
SHRUB LAYER										
Abies lasiocarpa	10	04	30	40	05	15	30	25	20	05
Picea engelmannii	04	01	--	--	15	.5	--	05	.5	02
Salix glauca	01	01	--	--	02	--	--	.5	.5	--
HERB-DWARF SHRUB LAYER										
Arnica cordifolia	01	--	--	.5	04	--	.5	--	--	--
Cassiope mertensiana	05	05	--	--	--	20	--	--	--	10
Cassiope tetragona	--	--	--	.5	05	--	.5	03	10	--
Empetrum nigrum	01	15	--	05	--	--	--	--	--	05
Pedicularis bracteosa	.5	--	--	.5	10	--	--	.5	--	--
Phyllodoce empetriformis	--	--	08	40	--	--	--	--	--	35
Phyllodoce glanduliflora	40	20	09	--	25	30	40	20	20	05
Pyrola secunda	01	--	--	--	--	01	.5	--	--	--
Vaccinium scoparium	03	45	03	30	10	02	05	10	05	05
BRYOID LAYER										
Barbilophozia hatcheri	--	--	--	--	10	--	.5	.5	05	10
Barbilophozia lycopodioides	10	--	01	02	--	20	--	02	--	--
Cladonia cenotea	--	--	--	--	--	.5	--	.5	--	02
Cladonia ecmocyna	--	--	.5	03	--	--	.5	05	05	04
Cladonia gonecha	--	--	.5	--	--	--	--	.5	.5	03
Dicranum scoparium	40	--	--	02	--	15	05	03	.5	05
Drepanocladus uncinatus	02	03	--	--	--	10	05	20	--	--
Hylocomium splendens	--	--	--	10	20	.5	40	40	40	05
Peltigera aphthosa	01	01	--	02	03	05	15	10	03	--
Pleurozium schreberi	10	05	45	75	--	40	30	05	20	20
EPIPHYTES										
Bryoria fremontii	--	--	--	--	--	.5	.5	--	--	.5
Bryoria glabra	--	--	--	--	--	--	.5	.5	.5	--
Letharia vulpina	--	--	.5	.5	--	.5	.5	.5	.5	.5
Parmeliopsis ambigua	--	--	.5	--	--	--	--	--	.5	--
Parmeliopsis hyperopta	--	--	.5	--	--	--	--	--	--	--
Usnea spp.	--	.5	--	--	--	--	--	.5	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The C34 v.t. stands are 200 to 400 years old and are mature successionally.

The C34 v.t. is distinguished from O10 by having a closed physiognomy and by slightly lower elevations, from C13 by greater cover of *Phyllodoce* spp., *Cassiope* spp., and *Vaccinium scoparium* and usually lower elevations, from C24 by *Salix vestita* cover <5% and *Equisetum scirpoides* cover <2%, and from C15 by the dominance of *Phyllodoce* spp. rather than *Vaccinium scoparium*.

Other Studies: Descriptions of similar types by other authors were not found.

C35: *Pinus contorta-(Picea engelmannii)/Empetrum nigrum/ Cladonia mitis*

(lodgepole pine-(Engelmann spruce)/crowberry/ lichen)

Environment: The C35 v.t. occurs on subxeric Lower Subalpine sites (1600-1850 m) on nearly level to moderate slopes on various aspects in northern Jasper. The soils are rapidly drained Eluviated Dystric Brunisols on noncalcareous glaciofluvial and ice contact stratified genetic materials.

Table 42 Stands representing the lodgepole pine-(Engelmann spruce) / crowberry / lichen (C35) v.t.

	JE 90 46	JE 90 48	JE 90 50	JE 91 38	LC 90 53	LC 91 65	PA 90 20	PA 90 24	PA 90 28	SJ 90 50
TREE LAYER										
Abies lasiocarpa	02	--	--	--	--	--	--	--	--	02
Picea engelmannii	05	--	14	02	03	05	.5	10	.5	08
Pinus contorta	29	35	14	28	22	25	35	30	35	10
TALL SHRUB LAYER										
Picea engelmannii	01	--	02	02	05	--	.5	.5	--	.5
Pinus contorta	.5	05	03	01	--	--	.5	.5	.5	.5
SHRUB LAYER										
Abies lasiocarpa	02	01	.5	01	--	--	.5	--	--	01
Juniperus communis	01	--	05	--	--	--	--	--	--	--
Picea engelmannii	.5	.5	.5	.5	--	--	03	--	--	02
Pinus contorta	.5	02	.5	.5	03	05	02	.5	05	03
HERB-DWARF SHRUB LAYER										
Abies lasiocarpa	.5	.5	.5	.5	--	.5	--	--	--	04
Cornus canadensis	.5	.5	.5	01	--	05	.5	05	.5	--
Elymus innovatus	--	--	--	02	--	--	.5	.5	01	--
Empetrum nigrum	27	14	05	04	20	10	20	35	30	35
Phyllodoce empetriformis	--	08	--	--	--	--	10	--	.5	02
Pinus contorta	--	.5	--	.5	01	02	--	--	--	02
Vaccinium caespitosum	--	05	20	--	05	02	--	--	--	07
Vaccinium vitis-idaea	--	03	--	02	02	02	05	05	.5	03
BRYOID LAYER										
Barbilophozia lycopodioides	.5	--	--	01	--	.5	--	--	--	.5
Cetraria ericetorum	--	.5	.5	.5	--	.5	--	--	.5	.5
Cladonia mitis	--	5	04	--	05	12	40	10	--	08
Cladonia cornuta	--	--	--	--	--	--	--	--	10	--
Cladonia crispata	--	.5	--	.5	--	.5	--	--	--	--
Cladonia ecmocyna	25	04	.5	18	10	05	.5	--	05	--
Cladonia gonecha	03	.5	--	01	05	02	--	--	--	.5
Cladonia gracilis	--	05	01	03	10	01	--	--	06	--
Cladonia uncialis	--	01	01	--	--	01	10	--	20	--
Dicranum brevifolium	--	10	03	02	15	02	--	--	.5	--
Hylocomium splendens	15	--	02	--	--	01	--	05	--	--
Peltigera aphthosa	--	--	--	.5	--	.5	.5	05	--	.5
Pleurozium schreberi	.5	--	.5	12	--	--	05	35	--	--
Rhizocarpon geographicum	--	.5	.5	.5	--	.5	.5	--	--	--
EPIPHYTES										
Letharia vulpina	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
Parmeliopsis ambigua	--	.5	.5	.5	--	.5	--	--	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: The tree layer is generally closed (25-40%), although some stands are more open with <20% cover (Table 42). *Pinus contorta* (25-35%) is usually dominant (Plate 35), often with lesser amounts of *Picea engelmannii* (5-8%), but occasionally *Picea engelmannii* is codominant. The shrub layer is

sparse (≤15%) and composed mostly of tree regeneration. The herb-dwarf shrub layer has 30 to 50% cover and is dominated by dwarf shrubs: *Empetrum nigrum* (15-35%), *Vaccinium vitis-idaea* (3%), *Vaccinium caespitosum* (4%). *Juniperus communis* occurs with high frequency but low cover. The bryoid layer is generally dense (40-65%) and dominated by lichens. Lichen cover is usually ≥25% and consists of *Cladonia mitis* (10-15%), *Stereocaulon tomentosum* (3-5%), *Peltigera aphthosa* (<1%), and various *Cladonia* spp. (3-10%), especially *C. uncialis, C gonecha,* and *C. cornuta. Letharia vulpina* is a common epiphyte.

Most stands are 175 to 250 years old and contain both *Pinus contorta* and *Picea engelmannii* regeneration. Thus, C35 appears stable on these dry sites and is advanced to mature successionally.

The C35 v.t. is distinguished from C9 by occurring in northern Jasper rather than Banff, by the usual absence of *Shepherdia canadensis*, by *Empetrum nigrum* dominance and lower *Vaccinium caespitosum* cover in the herb-dwarf shrub layer, and by a higher ground lichen cover, typically ≥25%.

Other Studies: Jeffrey (1964) described a related lodgepole pine-lichen woodland from the southwestern Northwest Territories.

C36: *Pinus contorta-Picea glauca/Salix glauca/ Elymus innovatus*

(lodgepole pine-white spruce/willow/hairy wild rye)

Environment: The C36 v.t. occurs on mesic to subhygric Lower Subalpine sites (1400-1700 m J, to 1900 m B) on gentle to moderate slopes on various aspects, primarily in the north end of Jasper. The soils are well drained Eutric Brunisols on fluvial landforms.

Vegetation: *Pinus contorta* is the dominant canopy tree with 10 to 25% cover (Table 43). *Picea glauca* is often present to co-dominant. The shrub layer, with a total cover of 25 to 45%, is dominated by *Salix glauca* (15-30%) with lesser amounts of *Betula glandulosa* (5-10%), *Shepherdia canadensis* (<5%), and *Ledum groenlandicum* (5%). Herb-dwarf shrub cover is 35 to 65% with *Elymus innovatus* (10-25%), *Linnaea borealis* (5%), *Epilobium angustifolium* (≤3%), and *Fragaria virginiana* (2-3%). The bryoid layer has a cover of 20 to 50% with *Hylocomium splendens, Pleurozium schreberi, Peltigera aphthosa,* and *Cladonia* spp. Epiphytes are scarce.

The C36 v.t. is intermediate successionally with stands generally 50 to 70 years old. Stands often show evidence of repeated burns at short intervals and *Picea glauca* is frequently present as remnants or snags.

Table 43 Stands representing the lodgepole pine-white spruce / willow / hairy wild rye (C36) v.t.

	JD 71 53	LC 90 05	LC 90 70	LC 90 75	PA 90 41	PA 90 43	PA 90 44	PA 91 36
TREE LAYER								
Picea glauca	20	15	05	03	20	25	05	05
Pinus contorta	13	15	10	05	25	05	35	35
TALL SHRUB LAYER								
Picea glauca	01	--	--	01	05	.5	10	--
Pinus contorta	.5	05	16	04	05	10	05	10
SHRUB LAYER								
Betula glandulosa	--	--	03	03	--	--	--	15
Betula pumila	--	12	--	--	05	10	--	--
Juniperus communis	.5	01	03	10	--	--	05	.5
Ledum groenlandicum	.5	.5	01	--	--	05	05	10
Pinus contorta	01	.5	--	--	--	--	--	05
Potentilla fruticosa	.5	--	--	03	05	--	.5	--
Salix glauca	05	12	15	16	15	20	30	35
Shepherdia canadensis	15	05	01	03	--	--	--	10
HERB-DWARF SHRUB LAYER								
Antennaria racemosa	.5	02	01	03	--	--	--	--
Elymus innovatus	30	06	15	10	25	05	20	30
Epilobium angustifolium	05	--	01	.5	03	02	03	--
Fragaria virginiana	01	--	02	02	03	03	02	--
Linnaea borealis	--	05	08	02	--	02	02	15
Vaccinium caespitosum	--	--	12	05	--	05	05	--
Equisetum scirpoides	20	.5	--	02	--	--	03	.5
Lycopodium annotinum	--	02	04	03	--	.5	.5	--
BRYOID LAYER								
Cladonia arbuscula	--	--	--	01	--	05	02	--
Cladonia crispata	--	--	--	--	05	--	04	--
Cladonia ecmocyna	--	--	08	03	--	--	--	--
Cladonia gracilis	--	--	02	--	--	--	06	10
Hylocomium splendens	--	05	09	03	01	25	30	05
Peltigera aphthosa	--	12	--	01	--	03	05	.5
Peltigera canina	--	--	--	--	05	--	05	--
Pleurozium schreberi	--	20	09	30	--	40	20	--
Polytrichum juniperinum	01	--	.5	--	--	--	--	05
Stereocaulon tomentosum	--	03	01	01	--	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

The C36 v.t. differs from C37 in having *Salix glauca* as the dominant shrub rather than *Shepherdia canadensis* and in being at an intermediate, rather than mature, successional stage. The C37 v.t. also occurs in the Montane as well as Lower Subalpine. The C36 v.t. also has some similarities to O18, but the latter is open forest, occurs in both Lower and Upper Subalpine, and has many different species in the herb-dwarf shrub layer despite similar dominance by *Elymus innovatus.*

Other Studies: Descriptions of similar types by other authors were not found.

C37: *Picea glauca/Shepherdia canadensis/Hylocomium splendens*

(white spruce/buffaloberry/feathermoss)

Environment: The C37 v.t. occurs on mesic Montane to Lower Subalpine (1000-1800 m) sites on various slopes and predominantly

northerly aspect in both Banff and Jasper. The soils are well drained Regosols and Eutric Brunisols on fluvial and morainal landforms. Deposition of calcareous loess appears to be less on these sites than in C2, C26 and C27.

Vegetation: *Picea glauca* (20-50%) is the dominant tree (Table 44). In Lower Subalpine stands, the *Picea* is frequently a *Picea glauca x P. engelmannii* hybrid. *Pinus contorta* occurs frequently with cover <10%. The shrub layer has a total cover of 10 to 60% and is dominated by *Shepherdia canadensis* (10-50%). *Juniperus communis, Salix glauca*, and *Rosa acicularis* occur with high frequency but with cover generally <10%. The herb-dwarf shrub layer has 20 to 50% cover and is dominated by *Elymus innovatus* (1-35%), *Linnaea borealis* (1-20%), and *Arctostaphylos uva-ursi* (<5%). Other species with high frequency but low cover are *Pyrola secunda, Fragaria virginiana, and Equisetum scirpoides*. The bryoid layer is well developed with a total cover of 40 to 80%. Generally, *Hylocomium splendens* is dominant (20-70%) with lesser amounts of *Pleurozium schreberi* (5-15%), *Ptilium crista-castrensis* (<5%), and *Peltigera aphthosa* (<5%). *Drepanocladus uncinatus* and *Thuidium abietinum* are often present but have low cover. Epiphytes are scarce.

Table 44 Stands representing the white spruce / buffaloberry / feathermoss (C37) v.t.

	AW	AW	IC	JC	JD	LC	LC	PA	PA	SJ
	60	70	90	80	90	90	90	70	70	90
	53	64	42	87	14	08	11	44	59	21
TREE LAYER										
Picea glauca	31	25	22	30	35	18	25	45	30	24
Pinus contorta	02	--	--	--	--	--	.5	.5	--	05
TALL SHRUB LAYER										
Picea glauca	07	.5	03	01	05	05	10	05	.5	07
SHRUB LAYER										
Juniperus communis	04	--	01	04	.5	--	.5	10	03	--
Ledum groenlandicum	--	--	--	--	.5	03	02	--	--	01
Rosa acicularis	.5	--	--	.5	02	--	--	01	--	02
Shepherdia canadensis	18	50	24	30	20	25	25	50	40	03
HERB-DWARF SHRUB LAYER										
Arctostaphylos uva-ursi	03	--	01	02	03	--	--	.5	.5	--
Arnica cordifolia	01	--	--	--	--	.5	--	.5	--	01
Aster conspicuus	05	12	--	03	--	--	--	10	.5	--
Carex concinna	--	--	.5	--	01	.5	--	--	.5	--
Elymus innovatus	02	18	01	13	15	25	12	10	08	05
Epilobium anguatifolium	--	--	--	02	.5	--	--	.5	.5	.5
Fragaria virginiana	--	--	.5	--	.5	.5	.5	--	--	--
Linnaea borealis	11	06	01	04	15	10	08	05	25	04
Mertensia paniculata	--	--	.5	--	01	.5	--	--	--	02
Pyrola asarifolia	--	--	.5	--	.5	01	--	--	--	01
Pyrola secunda	.5	--	.5	01	.5	--	01	.5	01	01
Equisetum scirpoides	--	--	.5	01	10	01	.5	--	10	--
BRYOID LAYER										
Hylocomium splendens	20	60	86	70	55	20	Bv	50	50	75
Peltigera aphthosa	18	05	01	--	01	.5	--	01	05	02
Peltigera rufescens	--	--	--	.5	--	--	--	--	.5	--
Pleurozium schreberi	55	--	--	04	15	08	--	--	--	20
Ptilium crista-castrensis	08	--	--	--	05	02	--	--	--	.5
Thuidium abietinum	--	--	02	15	.5	--	--	20	20	--
EPIPHYTES										
Hypogymnia physodes	--	--	--	--	.5	--	--	--	--	.5
Parmelia sulcata	--	--	.5	--	--	--	--	--	--	.5
Usnea alpina	--	--	--	--	.5	--	--	--	--	.5
Usnea scrediifera	--	--	.5	--	.5	--	--	--	--	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The C37 v.t. is mature successionally with most stands 125 to 300 years old. C37 appears to develop, following fire, often from *Pinus contorta* forest (C19, C6), but some C37 stands less than 100 years old contain little *P. contorta* and it appears that sometimes *Picea glauca* occupies the site immediately after fire rather than *P. contorta*.

The C37 v.t. differs from C26 (Table 10) by having *Hylocomium splendens* as the dominant bryoid rather than *Thuidium abietinum*, from C27 by having *Shepherdia canadensis* the dominant shrub and *Hylocomium splendens* the dominant bryoid rather than *Rosa acicularis* and *Thuidium abietinum*, and from C2 by having well-developed shrub and herb-dwarf shrub layers and *Hylocomium splendens* the dominant bryoid.

Other Studies: Similar types have been described by La Roi (1967, part of white spruce-fir), Douglas (1974) in the southwest Yukon (*Picea glauca/Shepherdia canadensis*), and Kondla (1978) in Kananaskis Provincial Park (spruce-fir/buffaloberry-grouseberry).

O2: *Pinus flexilis-Pseudotsuga menziesii/Juniperus* spp./*Arctostaphylos uva-ursi*

(limber pine-Douglas fir juniper/bearberry)

Environment: The O2 limber pine forest occurs on xeric to subxeric Montane (1340-1420 m), moderate to steeply sloping south facing erosional scarps along the lower Bow and North Saskatchewan Rivers in Banff. These sites are among the warmest and driest in the parks. Soils are rapidly drained Orthic Regosols developed on eroded glacial landforms.

Vegetation: *Pinus flexilis* is the predominant canopy tree or may be present only as a tall shrub (Plate 36). Total cover is 5 to 40%, creating a closed forest variant in some stands (Table 45). *Pseudotsuga menziesii* has 10 to 15% cover while *Picea glauca* has <5%. Shrub cover is high (30-50%) dominated by *Juniperus scopulorum* (15-20%) and *Juniperus communis* (5-10%), with a small amount of *Potentilla fruticosa* (<2%). *Juniperus scopulorum* is absent from the stands at Saskatchewan Crossing. Herb-dwarf shrub cover is moderate to high (30-55%) dominated by *Arctostaphylos uva-ursi* (20%) with other characteristic species being *Artemisia frigida* (<5%), *Erigeron caespitosus* (<4%), *Anemone patens* (<3%), *Oxytropis sericea* (<2%), *Carex filifolia* (<1%), and *Senecio canus* (<1%). Bryoid cover is low (<2%).

The O2 v.t. is successionally mature with stands 150 to 300 years old.

Table 45 Stands representing the limber pine-Douglas fir / juniper / bearberry (02) v.t.

	JC	KS
	80	51
	01	59
TREE LAYER		
Pinus flexilis	10	55
Pseudotsuga menziesii	02	--
Picea glauca	02	05
TALL SHRUB LAYER		
Pinus flexilis	04	15
SHRUB LAYER		
Amelanchier alnifolia	.5	--
Juniperus communis	03	08
Juniperus scopulorum	17	18
Pinus flexilis	--	10
Potentilla fruticosa	02	.5
Rosa acicularis	01	--
Shepherdia canadensis	.5	--
HERB-DWARF SHRUB LAYER		
Allium cernuum	.5	--
Anemone multifida	.5	--
Anemone patens	.5	03
Antennaria nitida	.5	--
Arctostaphylos uva-ursi	20	20
Artemisia campestris	--	01
Artemisia frigida	.5	05
Aster ciliolatus	.5	--
Aster sibiricus	--	.5
Astragalus spp.	.5	.5
Bromus ciliatus	--	06
Carex filifolia	.5	01
Erigeron caespitosus	.5	04
Festuca scabrella	--	01
Galium boreale	--	.5
Hedysarum mackenzii	.5	--
Koeleria cristata	--	08
Linum lewisii	.5	--
Oxytropis sericea	.5	02
Rosa acicularis	.5	--
Senecio canus	.5	.5
Trisetum spicatum	.5	--
Trisetum spp.	.5	--
BRYOID LAYER		
Barbula icmadophila	.5	--
Encalypta rhaptocarpa	.5	--
Pylaisiella polyantha	.5	--
Tortula ruralis	.5	--
Xanthoria elegans	.5	--
EPIPHYTES		
Letharia vulpina	.5	--
Parmelia infumata	.5	--
Parmelia subolivacea	.5	--
Usnea hirta	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The O2 v.t. is distinguished from all other v.t.s by the presence of *Pinus flexilis* and abundant *Juniperus scopulorum*. It is most similar to O5 in which *Pinus flexilis* is absent.

Other Studies: In Alberta, similar types were described by Kuchar (1973) for Waterton Lakes National Park (limber pine-scrub) and for the Porcupine Hills by Duffy (1971). In British Columbia, Kuchar (1978) described a similar type for Yoho National Park and in southern British Columbia, Brayshaw (1970) described a *Pseudotsuga menziesii-Pinus ponderosa-Arctostaphylos uva-ursi* type that is similar except that *Pinus ponderosa* appears to substitute for *Pinus flexilis*. In Montana, the *Pinus flexilis/Juniperus communis* type and *Juniperus* woodlands described by Pfister et al. (1977) are also similar.

O3: *Picea glauca/Potentilla fruticosa/Arctostaphylos uva-ursi*

(white spruce/shrubby cinquefoil/bearberry)

Environment: The O3 v.t. occurs predominantly on subxeric to mesic Montane (1000-1500 m), level to gently sloping sites of various aspect. A few stands occur above 1500 m in the Lower Subalpine. The soils are rapidly to well drained Regosols on fluvial landforms. The ground water regime can vary greatly within a stand depending on stand microtopography and seasonal variation in the depth to water table. Thus, several O3 stands have a subhygric moisture regime with imperfectly to poorly drained soils showing gley features.

Vegetation: *Picea glauca* (5-20%) is predominant in the open tree layer (Table 46 , Plate 37). A few stands with a closed tree layer are also included here as a closed variant. In Lower Subalpine stands, *Picea engelmannii* occasionally replaces *Picea glauca*. The shrub layer has a total cover of 10 to 40% and is dominated by *Potentilla fruticosa* (1-15%), *Shepherdia canadensis* (1-10%), and *Juniperus communis* (<10%). The herb-dwarf shrub layer has a total cover of 20 to 60%. Dominant species are *Arctostaphylos uva-ursi* (5-35%), *Elymus innovatus* (1-30%), and *Fragaria virginiana* (1-3%). The bryoid layer has a low cover (<30%) with the predominant species being *Thuidium abietinum* (1-10%), *Ditrichum flexicaule* (<3%), and *Peltigera canina* (<1%). Epiphytes are scarce.

The O3 v.t. is intermediate to mature successionally with stands 80 to 250 years old.

The O3 v.t. is closely related to O17 and intergrading stands occur. O3 is distinguished by: *Potentilla fruticosa* cover usually > 1% altitude usually <1500 m (Montane), landform usually fluvial, and soil usually Regosolic. In contrast, *Potentilla fruticosa* is typically absent in O17 or has <1% cover, the altitude is >1500 m (Lower Subalpine), the landform is colluvial or morainal, and the soil is Brunisolic or, if the landform is colluvial, the soil may be Regosolic.

Table 46 Stands representing the white spruce / shrubby cinquefoil / bearberry (03) v.t.

	AW 70 20	AW 70 99	IC 51 43	IC 80 03	IC 80 38	JB 81 32	JH 80 06	SJ 70 17	SJ 70 18	SJ 80 03
TREE LAYER										
Picea glauca	04	08	05	17	20	00	06	20	15	10
Pinus contorta	09	--	--	--	.5	--	01	--	--	--
Populus tremuloides	--	--	--	--	--	--	.5	.5	03	--
TALL SHRUB LAYER										
Betula occidentalis	--	--	.5	02	--	--	--	--	01	--
Picea glauca	15	10	--	01	03	01	.5	20	10	06
Pinus contorta	03	--	--	--	--	--	--	--	--	--
Populus tremuloides	--	--	--	--	--	--	01	--	03	--
SHRUB LAYER										
Betula glandulosa	01	02	.5	01	--	.5	--	--	--	--
Juniperus communis	06	.5	02	01	05	--	20	02	01	02
Picea glauca	05	06	--	01	05	01	01	--	--	06
Potentilla fruticosa	02	08	03	06	02	03	01	01	02	16
Rosa acicularis	06	--	03	01	--	--	03	02	06	--
Shepherdia canadensis	03	02	05	.5	02	08	05	20	05	.5
HERB-DWARF SHRUB LAYER										
Achillea millefolium	--	.5	--	--	--	.5	--	06	--	--
Androsace chamaejasme	.5	.5	--	.5	.5	--	01	--	03	04
Anemone multifida	01	--	--	--	--	.5	--	02	--	--
Antennaria nitida	--	--	--	--	--	--	--	04	--	06
Arctostaphylos uva-ursi	50	15	25	15	30	06	15	07	40	38
Aster ciliolatus	--	--	--	.5	--	--	02	01	--	--
Carex concinna	--	03	05	05	05	--	--	03	--	--
Carex aburnea	--	--	--	.5	.5	--	--	01	01	06
Carex scirpoidea	02	--	--	01	--	--	--	--	--	22
Carex spp.	20	--	--	--	--	--	.5	--	--	--
Elymus innovatus	02	.5	.5	08	15	20	10	15	10	.5
Fragaria virginiana	.5	01	--	01	--	.5	--	06	03	--
Hedysarum alpinum	--	--	--	01	10	--	03	--	--	10
Hedysarum sulphurescens	01	--	--	--	--	03	--	--	--	--
Juniperus horizontalis	--	--	.5	15	05	--	--	--	02	12
Linnaea borealis	02	--	--	.5	--	01	--	08	--	--
Solidago decumbens	--	--	.5	--	.5	--	--	03	--	04
Zygadenus elegans	--	--	.5	01	.5	--	01	--	10	14
BRYOID LAYER										
Bryum spp.	--	--	--	--	.5	.5	--	--	--	--	.5
Cetraria nivalis	--	--	--	--	--	.5	.5	--	--	--	--
Cladonia pyxidata	--	--	--	--	--	01	.5	.5	--	--	--
Distichium capilleceum	--	--	--	--	.5	--	--	--	.5	--	.5
Ditrichum flexicaule	--	03	--	--	01	--	--	02	05	.5
Drepanocladus uncinatus	--	02	--	--	--	--	--	--	--	--
Hypnum revolutum	--	--	--	--	--	02	.5	--	--	01	--
Peltigera canina	--	.5	--	--	--	--	.5	.5	.5	--	.5
Thuidium abietinum	--	--	--	--	10	12	.5	01	.5	01	.5
Tortella tortuosa	--	--	--	--	--	--	--	--	--	--	.5
Tortula ruralis	--	--	--	--	--	--	--	--	.5	01	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Other Studies: Similar types have been described from Jasper by Laidlaw (1971, *Picea mariana-Potentilla*) and La Roi (1975, *Picea glauca/Potentilla fruticosa/Arctostaphylos uva-ursi/Thuidium abietinum, Picea glauca/Elaeagnus commutata/Potentilla fruticosa/Arctostaphylos uva-ursi*).

O4: *Picea engelmannii-Abies lasiocarpa-Pinus albicaulis-Pinus contorta*

(Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine)

Environment: The O4 v.t. occurs on predominantly subxeric, Lower Subalpine to Upper Subalpine (1525-2250 m B, 1650-2250 m J), generally steeply sloping sites with southerly aspect. Soils are rapidly to well drained Orthic Eutric Brunisols, Orthic Regosols and Dystric Brunisols on colluvial and morainal landforms.

Vegetation: *Picea engelmannii*, *Abies lasiocarpa*, *Pinus albicaulis*, and *Pinus contorta* are codominant or any one of these species may be dominant in this heterogeneous mixed coniferous v.t. (Plate 38) which has tree cover usually <20% (Table 47). *Pseudotsuga menziesii* occurs in some low elevation stands. The shrub layer has moderate cover (10-45%), the dominants being *Juniperus communis* (3-20%) and *Shepherdia canadensis*

Table 47 Stands representing the Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (04) v.t.

	AW 51 19	AW 60 56	GN 60 32	IC 90 38	IC 90 86	JD 71 21	JD 90 43	JE 90 67	PA 70 55	PA 70 71
TREE LAYER										
Abies lasiocarpa	02	--	03	--	.5	--	--	04	--	05
Picea engelmannii	01	12	10	02	04	05	05	06	--	--
Pinus albicaulis	14	18	07	05	06	--	03	10	10	10
Pinus contorta	--	--	--	--	--	--	01	--	--	--
TALL SHRUB LAYER										
Abies lasiocarpa	.5	--	06	01	01	--	--	01	--	05
Picea engelmannii	--	--	01	03	.5	01	01	03	.5	--
Pinus albicaulis	02	.5	03	04	.5	02	08	05	05	05
Pinus contorta	--	--	--	.5	--	--	01	--	--	--
SHRUB LAYER										
Abies lasiocarpa	02	--	10	.5	11	01	--	05	01	01
Juniperus communis	12	03	19	01	.5	03	02	05	--	--
Juniperus horizontalis	--	--	04	--	--	--	--	--	--	--
Picea engelmannii	--	.5	--	04	--	--	--	.5	.5	--
Pinus albicaulis	--	01	--	08	01	.5	10	.5	02	--
Potentilla fruticosa	01	.5	02	--	--	.5	01	--	--	--
Rosa acicularis	--	.5	04	--	--	--	--	--	--	--
Salix glauca	--	--	--	.5	01	--	.5	--	--	02
Salix vestita	--	--	--	--	02	--	02	--	--	--
Shepherdia canadensis	.5	03	10	02	--	--	01	15	.5	.5
HERB-DWARF SHRUB LAYER										
Abies lasiocarpa	--	--	03	--	.5	--	--	.5	--	.5
Achillea millefolium	.5	03	03	.5	--	--	--	.5	--	.5
Androsace chamaejasme	--	04	--	--	--	.5	--	--	--	--
Antennaria nitida	--	01	02	--	--	--	--	--	--	--
Antennaria parviflora	--	--	--	--	--	--	02	--	--	--
Antennaria racemosa	--	--	--	01	02	--	05	01	03	.5
Aquilegia flavescens	.5	--	--	--	02	--	01	.5	--	.5
Arnica cordifolia	--	--	--	--	--	--	01	--	02	--
Arctostaphylos rubra	--	--	--	--	01	--	10	--	.5	--
Arctostaphylos uva-ursi	06	04	05	11	--	03	03	--	.5	--
Aster campestris	--	--	--	--	--	--	.5	--	--	--
Aster ciliolatus	--	--	--	--	--	--	--	.5	--	--
Aster conspicuus	--	--	03	--	--	--	--	--	--	--
Bromus pumpellianus	--	--	01	--	--	.5	--	--	--	--
Campanula rotundifolia	--	03	--	--	--	--	--	--	--	--
Carex concinna	--	--	--	01	.5	--	02	--	--	--
Carex scirpoidea	--	--	--	--	--	02	02	--	--	--
Carex rupestris	--	--	--	--	--	05	--	--	--	--
Cassiope tetragona	--	--	--	--	--	--	--	--	05	--
Dryas octopetala	--	--	--	01	--	15	01	--	02	--
Elymus innovatus	01	15	02	06	.5	--	10	08	05	.5
Epilobium angustifolium	--	--	03	--	--	--	.5	.5	--	05
Erigeron peregrinus	.5	04	01	--	02	--	--	--	03	02
Fragaria virginiana	--	--	03	01	--	--	.5	01	--	01
Hedysarum sulphurescens	--	--	02	--	--	--	--	--	--	--
Juniperus communis	--	--	--	--	--	--	--	--	10	05
Linnaea borealis	.5	--	--	03	11	--	--	--	01	--
Parnassia fimbriata	--	--	--	--	01	--	01	--	--	--
Pedicularis bracteosa	--	--	--	.5	03	--	01	--	.5	--
Poa cusickii	--	--	04	--	--	--	--	--	--	--
Sedum stenopetalum	--	.5	--	.5	--	01	--	--	--	01
Senecio lugens	--	--	02	--	--	--	--	--	--	--
Solidago decumbens	--	--	01	.5	.5	01	--	--	--	--
Solidago multiradiata	01	--	06	--	--	--	.5	.5	.5	.5
Zygadenus elegans	.5	--	--	01	01	--	03	01	.5	--
Selaginella densa	--	06	--	01	--	--	.5	--	--	--
BRYOID LAYER										
Dicranum spp.	--	.5	--	--	10	--	--	--	--	--
Drepanocladus uncinatus	--	--	--	.5	07	--	--	--	--	--
Hypnum recurvatum	--	--	--	--	10	--	--	--	--	--
Peltigera aphthosa	--	--	--	--	02	--	--	--	--	--
Peltigera canina	--	.5	--	.5	01	--	--	--	--	--
Peltigera rufescens	--	--	--	.5	--	--	.5	.5	--	--
Tortella tortuosa	--	--	01	--	.5	--	02	.5	--	--
Tortula norvegica	--	--	02	.5	--	--	--	--	--	--
Tortula ruralis	--	.5	--	.5	--	--	01	--	02	.5
Barbilophozia hatcheri	--	--	--	--	04	--	--	--	--	--
Barbilophozia lycopodioides	--	--	--	--	04	--	--	--	--	--
EPIPHYTES										
Lotharia vulpina	--	.5	.5	.5	--	--	.5	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

(<15%). The herb-dwarf shrub layer also has moderate cover (10-30%) and is dominated by *Elymus innovatus* (3-15%), *Arctostaphylos uva-ursi* (3-25%), *Linnaea borealis* (<10%), *Zygadenus elegans* (<3%), and *Fragaria virginiana* (<10%). The bryoid layer has usually low cover (<15%) with few species of high frequency. *Pleurozium schreberi* and *Dicranum* spp. may be locally abundant while *Cladonia* spp., *Peltigera rufescens* and *Peltigera aphthosa* are the predominant lichens.

Successionally, O4 is intermediate to mature often with several age classes represented.

The O4 v.t. is distinguished from other open forest types by the usual codominance or dominance of *Pinus albicaulis*. Stands transitional to C3 at low elevations and to O10 at high elevations occur.

Other Studies: Several of the timberline types described by Baig (1972) for the Alberta Rocky Mountains show strong similarity: *Abies-Pinus albicaulis-Picea/Phyllodoce*, *Pinus albicaulis-Picea-Abies/Juniperus communis*, *Pinus albicaulis-Abies/Salix vestita*, *Picea-Pinus albicaulis/Salix glauca*, and *Abies-Pinus albicaulis*. Hettinger (1975) described a similar type in Jasper (*Picea-Pinus albicaulis/Juniperus communis/Elymus*). In Montana, Pfister et al. (1977) described a *Pinus albicaulis-Abies lasiocarpa* type which is similar to the more mesic Banff-Jasper vegetation while his *Pinus albicaulis* type is similar to more xeric Banff-Jasper *Pinus albicaulis* open forest.

O5: *Pseudotsuga menziesii/Juniperus communis/Arctostaphylos uva-ursi*

(Douglas fir/juniper/bearberry)

Environment: The O5 Douglas fir forest occurs on xeric to subxeric Montane (1320-1520 m), moderate to steeply sloping erosional scarps with southerly aspects; e.g. above the Bow River. Soils are very rapidly to rapidly drained Regosols and Orthic Eutric Brunisols developed on gullied glacial landforms. These sites are among the warmest and driest in the parks.

Vegetation: *Pseudotsuga menziesii* (5-25%) is the dominant tree (Table 48). *Picea glauca* (<5%) is present in one-half the sampled stands. Total tree cover is 5 to 55% (Plate 39). The shrub layer has low to moderate cover (12-55%) and is dominated by *Juniperus communis* (5-15%) and *Pseudotsuga menziesii* regeneration (5-25%) with lesser amounts of *Rosa acicularis* (<2%) and *Spiraea lucida* (≤1%). The herb-dwarf shrub layer has moderate cover (35-60%) with characteristic species being *Arctostaphylos uva-ursi* (5-40%), *Senecio canus* (1-8%), *Agropyron spicatum* (5-20%), *Koeleria cristata* (<6%), and *Galium boreale* (≤2%). Bryophyte and lichen cover is low (<1%) and sporadic, and epiphytes are scarce.

Table 48 Stands representing the Douglas fir juniper / bearberry (05) v.t.

	AW 51 47	AW 60 38	AW 60 41	KS 51 56	KS 51 57	KS 57 60
TREE LAYER						
Picea glauca	.5	04	02	--	--	--
Pinus contorta	--	01	--	--	--	--
Populus tremuloides	--	05	--	--	--	--
Pseudotsuga menziesii	07	03	03	50	55	50
TALL SHRUB LAYER						
Picea glauca	01	--	--	--	--	--
Pinus contorta	--	--	--	02	--	--
Pseudotsuga menziesii	03	--	--	10	05	02
SHRUB LAYER						
Amelanchier alnifolia	--	01	01	--	--	01
Juniperus communis	09	04	09	15	08	10
Juniperus horizontalis	12	--	--	02	05	--
Juniperus scopulorum	04	--	--	03	06	--
Picea glauca	--	01	--	--	--	--
Pinus contorta	--	.5	--	05	--	--
Potentilla fruticosa	.5	--	--	.5	--	--
Pseudotsuga menziesii	01	.5	--	15	10	05
Rosa acicularis	.5	--	01	02	.5	02
Rosa woodsii	--	01	--	--	--	--
Shepherdia canadensis	01	06	--	.5	--	--
Spiraea lucida	.5	.5	--	01	--	01
Symphoricarpos albus	--	--	--	--	.5	01
Symphoricarpos occidentalis	--	.5	.5	--	--	--
HERB-DWARF SHRUB LAYER						
Achillea millefolium	01	.5	.5	.5	02	.5
Agropyron spicatum	05	--	--	12	08	20
Allium cernuum	.5	.5	.5	.5	.5	--
Anemone canadensis	--	01	--	--	--	--
Anemone multifida	.5	01	--	--	--	--
Anemone patens	--	--	--	.5	.5	02
Antennaria nitida	.5	--	--	02	04	01
Arabis holboellii	--	--	.5	.5	.5	--
Arctostaphylos uva-ursi	32	40	18	18	05	05
Artemisia frigida	01	--	--	--	.5	02
Aster ciliolatus	--	--	--	02	02	.5
Astragalus decumbens	--	.5	01	--	.5	--
Calamagrostis purpurascens	--	--	--	--	--	05
Campanula rotundifolia	.5	.5	--	.5	--	--
Carex concinna	--	03	--	--	--	.5
Castilleja miniata	--	02	--	--	--	--
Commandra pallida	.5	--	.5	--	--	--
Elymus innovatus	--	02	--	--	--	.5
Erigeron compositus	03	--	01	--	--	--
Festuca saximontana	.5	--	--	01	.5	--
Gaillardia aristata	.5	--	.5	01	--	.5
Galium boreale	.5	02	01	.5	--	.5
Hedysarum mackenzii	--	01	--	--	--	--
Hedysarum sulphurescens	--	04	--	--	--	--
Koeleria cristata	.5	01	03	06	--	.5
Linum lewisii	.5	--	01	--	--	02
Oxytropis campestris	--	--	--	.5	.5	--
Oxytropis deflexa	.5	.5	.5	--	--	--
Penstemon confertus	.5	--	--	--	.5	--
Poa spp.	--	.5	--	--	--	03
Senecio canus	01	.5	01	05	08	.5
Solidago decumbens	.5	--	--	.5	--	--
Stipa richardsonii	--	--	--	15	--	--
Artemisia spp.	--	--	03	--	--	--
Selaginella densa	04	--	--	--	--	--
BRYOID LAYER						
Drepanocladus uncinatus	.5	--	--	--	--	--
Eurhynchium pulchellum	--	--	--	--	--	.5
Peltigera rufescens	--	--	--	--	--	.5
Thuidium abietinum	--	--	--	--	--	.5
Tortula ruralis	--	--	--	.5	--	--
EPIPHYTES						
Letharia spp.	--	--	--	.5	--	--
Parmelia spp.	--	--	--	.5	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The O5 v.t. is successionally mature with stands 75 to >300 years old.

The O5 v.t. is distinguished from O2 by the absence of *Pinus flexilis* and less frequent occurrence of *Juniperus scopulorum* but occurs in very similar environments. The O5 v.t. is distinguished from C1 by having high *Arctostaphylos uva-ursi* and *Agropyron spicatum* cover and low *Elymus innovatus* cover.

Other Studies: Similar types have been described by Kuchar (1973) in Waterton Lakes National Park (conifer savanna, dominated by *Pseudotsuga menziesii*), Kuchar (1978) in Yoho National Park (Douglas fir/common juniper), and also in southern British Columbia, by Beil (1974, *Pseudotsuga menziesii/Arctostaphylos uva-ursi*).

O6: *Picea engelmannii-Abies lasiocarpa/Salix* spp./*Aulacomnium palustre*

(Engelmann spruce-subalpine fir/willow/ribbed bog moss)

Environment: The O6 v.t. occurs on hygric to hydric, Subalpine (1500-2000 m) gently sloping sites of various aspect. Soils are predominantly poorly and very poorly drained Gleysols and Terric Mesisols developed on fluvial landforms.

Vegetation: *Picea engelmannii* (3-15%) is the dominant tree (Table 49). *Abies lasiocarpa* is occasionally present with cover <5%. Total tree cover is generally <15% (Plate 40). The shrub layer is usually dense (15-80%) and dominated by *Salix glauca* (5-20%) although *S. barrattiana* (10-15%) may be dominant at higher elevations. *Betula glandulosa* (<15%) and *Ledum groenlandicum* (<15%) are usually present. *Potentilla fruticosa* (1-10%) is often present also. The herb-dwarf shrub layer is well developed (30-100%) and is dominated by *Carex* spp. of which *Carex vaginata* (5-30%) and *Carex aquatilis* (10-40%) are usually most abundant. Other common herbs are *Equisetum arvense* (1-15%), *Equisetum variegatum* (<2%), and *Pedicularis bracteosa* (<3%). *Arctostaphylos rubra* (<5%), *Empetrum nigrum* (1-3%), and *Kalmia polifolia* (<5%) often occur on better drained hummocks. The bryoid layer is generally well developed (20-90%) with the dominant species being *Aulacomnium palustre* (10-40%) and *Tomenthypnum nitens* (10-35%). Terrestrial lichens and epiphytes are sparse.

Successionally, O6 is mature with open canopies being maintained by excessive wetness. Stand age may exceed 300 years.

	AN 50 61	AW 70 23	GM 60 48	IC 80 54	JD 80 05	JE 90 55	JE 90 66	PA 70 29	PA 71 32	PA 90 04
TREE LAYER										
Abies lasiocarpa	--	--	01	04	--	02	03	--	--	--
Picea engelmannii	06	24	08	06	15	10	13	10	02	03
Picea mariana	--	--	--	--	--	--	--	--	--	07
Pinus contorta	--	01	--	--	--	--	--	--	08	--
TALL SHRUB LAYER										
Abies lasiocarpa	--	.5	04	01	--	03	01	.5	--	--
Picea engelmannii	--	03	04	04	03	--	01	05	.5	--
Picea glauca	--	--	--	--	--	03	--	--	--	--
Picea mariana	--	--	--	--	--	--	--	--	--	05
SHRUB LAYER										
Abies lasiocarpa	--	06	03	10	--	.5	08	--	--	--
Betula glandulosa	11	17	--	--	01	15	05	--	15	10
Betula pumila	--	--	08	01	--	--	--	--	--	--
Ledum groenlandicum	03	02	--	08	--	15	--	--	.5	05
Lonicera involucrata	--	--	--	--	.5	--	--	10	--	--
Picea engelmannii	03	03	05	10	01	--	.5	.5	--	--
Potentilla fruticosa	09	02	29	--	--	05	--	--	10	--
Salix barrattiana	07	01	--	15	--	--	15	.5	10	--
Salix bebbiana	--	23	--	--	--	--	--	--	--	--
Salix brachycarpa	--	--	--	03	--	--	--	--	--	--
Salix farrae	02	--	--	--	--	--	--	15	--	--
Salix glauca	--	--	20	05	75	20	--	--	--	--
Salix myrtillifolia	--	--	--	--	--	05	03	--	--	20
Salix vestita	02	01	--	--	--	--	01	--	05	--
HERB-DWARF SHRUB LAYER										
Anemone parviflora	.5	.5	--	--	--	.5	.5	--	--	.5
Arctostaphylos rubra	--	--	--	--	--	18	01	--	--	05
Arnica cordifolia	--	--	--	--	05	--	--	--	--	--
Aster ciliolatus	--	--	--	--	10	--	--	.5	--	--
Carex aquatilis	03	--	--	01	--	--	--	--	--	--
Carex nigricans	--	--	35	--	--	--	--	--	--	--
Carex scirpoides	30	--	--	--	--	--	35	--	40	--
Carex vaginata	15	07	--	01	--	35	--	--	--	--
Carex spp.	--	--	--	--	65	--	--	10	--	--
Cassiope tetragona	--	--	--	--	02	--	--	--	10	--
Deschampsia caespitosa	--	--	--	--	--	--	--	02	--	--
Empetrum nigrum	05	08	--	03	--	--	--	--	--	02
Epilobium angustifolium	--	--	--	--	10	--	--	01	--	--
Erigeron peregrinus	04	--	04	--	--	--	--	--	01	--
Eriophorum scheuchzeri	--	--	--	--	--	--	--	--	--	05
Fragaria virginiana	--	--	--	--	--	15	--	.5	02	--
Juniperus communis	--	--	--	--	--	--	--	.5	05	--
Kalmia polifolia	03	--	--	01	--	--	01	01	03	--
Ledum groenlandicum	--	--	--	--	--	--	--	10	--	--
Linnaea borealis	--	--	04	--	--	03	--	--	--	--
Oxycoccus microcarpus	--	--	--	.5	--	--	--	--	--	08
Parnassia fimbriata	.5	--	04	--	--	--	01	.5	--	--
Pedicularis bracteosa	.5	.5	--	--	--	01	01	.5	.5	--
Petasites sagittatus	--	--	--	--	05	--	--	--	--	--
Petasites vitifolius	--	--	--	--	03	--	--	01	--	--
Phyllodoce empetriformis	23	--	--	--	--	--	02	--	--	--
Phyllodoce glanduliflora	--	--	--	--	--	--	--	--	10	--
Polygonum viviparum	02	.5	--	--	--	--	--	.5	.5	.5
Pyrola asarifolia	--	--	--	--	--	.5	.5	--	.5	--
Pyrola minor	--	--	02	--	--	--	--	.5	--	--
Rubus acaulis	--	--	--	--	02	--	--	.5	--	.5
Senecio [illegible] angularis	--	--	--	--	--	--	01	03	--	--
Trisetum spicatum	--	--	03	--	--	--	--	--	--	--
Trollius albiflorus	02	--	03	--	--	--	.5	.5	--	--
Vaccinium caespitosum	--	--	--	02	--	--	.5	--	--	.5
Vaccinium scoparium	--	12	03	--	.5	--	03	--	.5	--
Vaccinium vitis-idaea	--	03	--	02	--	.5	--	--	--	05
Valeriana sitchensis	--	--	--	--	5	--	02	--	--	--
Equisetum scirpoides	--	.5	--	.5	02	--	--	01	--	10
Equisetum variegatum	.5	--	--	.5	--	02	--	.5	--	--
BRYOID LAYER										
Aulacomnium palustre	.5	04	15	20	35	.5	15	40	10	10
Bryum pseudotriquetrum	--	--	--	.5	01	.5	.5	--	--	--
Campylium chrysophyllum	--	--	--	--	--	--	--	--	05	--
Campylium stellatum	03	--	03	--	--	.5	.5	--	--	--
Cladonia ecmocyna	--	.5	--	--	.5	--	--	.5	--	--
Cladonia spp.	--	15	--	02	02	--	02	.5	.5	02
Cratoneuron commutatum	--	--	--	--	--	.5	--	05	--	.5
Dicranum muehlenbeckii	--	--	--	--	01	--	20	--	--	--
Dicranum scoparium	--	01	--	--	01	--	--	--	10	--
Dicranum undulatum	20	--	--	--	--	--	--	--	--	.5
Dicranum spp.	--	--	--	10	--	--	--	--	--	--
Drepanocladus revolvens	08	--	--	.5	--	--	.5	--	--	03
Drepanocladus uncinatus	--	.5	06	--	.5	--	--	--	--	--
Hylocomium splendens	--	40	--	20	--	30	--	--	--	--
Peltigera aphthosa	--	02	--	01	01	--	.5	--	--	--
Peltigera spp.	--	--	--	--	--	--	--	--	--	05
Pleurozium schreberi	04	18	02	15	08	--	--	--	--	--
Polytrichum juniperinum	--	01	--	.5	01	--	--	01	--	--
Polytrichum strictum	12	--	--	--	--	--	--	--	--	.5
Sphagnum fuscum	--	--	--	--	--	--	--	--	--	05
Sphagnum warnstorfii	25	--	--	05	--	--	--	10	--	10
Tomenthypnum nitens	09	--	--	15	02	35	10	10	25	60
Tortella fragilis	--	--	--	--	--	--	--	05	--	--
Tortella tortuosa	--	--	--	15	--	--	--	--	--	--
Barbilophozia hatcheri	--	.5	04	.5	--	--	--	--	--	--
Barbilophozia lycopodioides	--	--	--	02	--	--	.5	--	--	--
EPIPHYTES										
Cetraria pinastri	--	--	--	--	.5	.5	--	--	--	--
Letharia vulpina	--	--	--	--	--	--	--	.5	.5	--
Usnea sorediifera	--	--	--	.5	--	.5	--	--	--	--

Table 49 Stands representing the Engelmann spruce-subalpine fir / willow / ribbed bog moss (06) v.t.

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The O6 v.t. is distinguished from O18 by being much wetter and having more abundant *Carex* spp. Sparsely treed stands may be transitional to S1.

Other Studies: Descriptions of similar types by other authors were not found.

O7: *Picea glauca-Picea mariana/Triglochin maritima-Carex* spp.

(spruce/arrowgrass-sedge)

Environment: The O7 v.t. occurs on hygric to subhydric Montane sites (1000-1200 m) on level to very gentle slopes of various aspect, primarily in the Athabasca valley below Jasper townsite. The soils are poorly drained Gleysols on fluvial landforms. Stands of O7 often have a hummocky microtopography.

Table 50 Stands representing the spruce / arrowgrass-sedge (07) v.t.

	1C 1C TL TL TL
	7C 7C 02 06 03
	22 28
	.2
	TREE LAYER
Picea glauca	-- 03 04 02 .5
Picea mariana	15 03 11 11 29
	SHRUB LAYER
Betula pumila	-- .5 .5 02 .5
Potentilla fruticosa	01 05 04 14 03
Salix candida	-- -- .5 .5 .5
Salix myrtillifolia	15 -- 02 07 15
Salix spp.	40 -- .5 .5 .5
	HERB-DWARF SHRUB LAYER
Calamagrostis canadensis	-- -- .5 .5 .5
Carex aquatilis	-- 10 .5 -- 02
Carex aurea	10 -- -- 02 .5
Carex capillaris	05 -- .5 05 .5
Carex spp.	.5 .5 05 19 .5
Equisetum arvense	10 .5 .5 -- --
Juncus balticus	05 .5 .5 -- --
Tofieldia glutinosa	.5 -- .5 01 --
	BRYOID LAYER
Campylium stellatum	-- .5 .5 18 .5
Ditrichum flexicaule	-- -- 23 .5 --
Drepanocladus revolvens	-- .5 .5 -- 17
Tomenthypnum nitens	35 .5 .5 .5 03

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: The tree layer is open with <15% cover (Table 50). *Picea glauca* and *Picea mariana* are dominant. The shrub layer is moderately dense (15-30%) and is dominated by *Potentilla fruticosa*, *Salix* spp. (especially *Salix myrtillifolia* and *Salix candida*), and *Betula pumila*. Total herb-dwarf shrub layer cover is 30 to 60% with *Triglochin maritima*, *Carex* spp. (especially *Carex aquatilis*, *Carex aurea*, and *Carex capillaris*), *Juncus balticus*, *Tofieldia glutinosa*, and *Equisetum arvense* most important. The bryoid layer usually has a total cover of <35% since there are often patches of marly, bare mineral soil. The most common species are *Tomenthypnum nitens*, *Drepanocladus revolvens*, *Campylium stellatum*, and *Ditrichum flexicaule*.

The O7 v.t. is mature successionally.

The O11 v.t. differs from O7 in occurring at higher altitudes and by having *Ledum groenlandicum* the dominant shrub. Also, O7 generally lacks *Sphagnum* spp. in the bryoid layer.

Other Studies: Jacques and Legge (1974) described a similar type (*Picea/Carex* spp.) from the Kananaskis area.

O9: *Picea engelmannii-Abies lasiocarpa/Valeriana sitchensis-Erigeron peregrinus*

(Engelmann spruce-subalpine fir/valerian-fleabane)

Environment: The O9 v.t. occurs on mesic to subhygric Upper Subalpine sites (2000-2310 m B, 1800-2100 m J) on various slopes and aspects. Soil drainage ranges from well to poorly drained with seepage often present. Seasonality of seepage may account partly for the wider range of drainage classes compared with the moisture regime range (mesic to subhygric). The soils are similarly varied, consisting of Eutric and Dystric Brunisols, Orthic Melanic Brunisols and Gleysols. The landforms are morainal and fluvial.

Vegetation: The tree layer is open with 5 to 20% cover and is dominated by *Picea engelmannii* (5-20%) and *Abies lasiocarpa* (5-10%) (Table 51). The shrub layer is generally sparse (<15%) with *Abies lasiocarpa* (5-10%) and *Picea engelmannii* (1-5%) most common. The herb-dwarf shrub layer is species-rich and has a total cover of 60 to 90% (Plate 41). Dominant species are *Valeriana sitchensis* (5-15%), *Erigeron peregrinus* (5-10%), *Trollius albiflorus* (5-10%), *Vaccinium scoparium* (5-15%), and *Cassiope mertensiana* (5-10%). *Artemisia norvegica* (5-10%) is characteristic of Jasper stands, although *Artemisia norvegica* also occurs in Banff north of the North Saskatchewan River. *Erythronium grandiflorum* (5-10%) is likewise characteristic of Banff stands, but it also extends to northern Jasper. Other important species are *Pedicularis bracteosa* (1-3%), *Senecio triangularis* (1-20%), *Anemone occidentalis* (2-5%), and *Phyllodoce empetriformis* (1-5%). Common species with low cover include *Antennaria lanata*, *Arnica cordifolia*, *Fragaria virginiana*, *Sibbaldia procumbens*, *Veratrum eschscholtzii*, and, in northern Jasper, *Lupinus nootkatensis*. Bryoid cover is variable (1-80%) with *Dicranum scoparium*, *Drepanocladus uncinatus*, *Aulacomnium palustre*, *Barbilophozia lycopodioides*, *Cladonia* spp., and *Peltigera aphthosa* most common.

Table 51 Stands representing the Engelmann spruce-subalpine fir / valerian-fleabane (09) v.t.

	AW	IC	IC	JB	JB	JN	JN	LC	PA	SJ
	60	90	91	91	91	70	70	91	90	91
	93	95	03	01	78	65	81	18	88	00
TREE LAYER										
Abies lasiocarpa	23	16	09	.5	06	09	.5	05	05	06
Picea engelmannii	27	01	15	08	05	10	07	10	10	07
TALL SHRUB LAYER										
Abies lasiocarpa	02	05	03	.5	02	03	03	08	.5	--
Picea engelmannii	.5	--	.5	01	01	--	01	02	.5	.5
SHRUB LAYER										
Abies lasiocarpa	16	08	05	01	10	13	.5	.5	--	05
Picea engelmannii	--	--	--	.5	01	--	--	01	.5	02
Salix spp.	--	.5	03	09	04	--	07	10	10	03
HERB-DWARF SHRUB LAYER										
Abies lasiocarpa	--	18	--	--	05	--	--	02	.5	--
Anemone occidentalis	--	05	--	--	.5	--	03	02	.5	--
Antennaria lanata	--	01	--	.5	--	--	--	01	--	--
Arnica cordifolia	.5	--	--	--	.5	--	--	05	03	01
Arnica latifolia	--	--	05	--	--	--	--	02	--	--
Artemisia norvegica	--	--	--	25	12	--	02	10	35	--
Cassiope mertensiana	.5	--	--	--	--	--	01	--	03	--
Equisetum arvense	--	--	01	--	--	--	07	10	--	--
Erigeron peregrinus	.5	02	--	--	01	--	05	05	05	05
Erythronium grandiflorum	--	--	04	--	--	--	--	--	--	--
Fragaria virginiana	--	.5	--	03	.5	--	--	--	03	05
Lupinus nootkatensis	--	--	.5	--	--	--	--	--	--	--
Pedicularis bracteosa	01	03	01	05	01	.5	03	08	15	01
Phyllodoce empetriformis	.5	--	--	01	--	02	--	08	05	.5
Phyllodoce glanduliflora	--	--	--	--	--	05	05	--	--	--
Polygonum viviparum	.5	.5	.5	--	--	--	--	--	.5	.5
Senecio triangularis	.5	--	--	--	--	--	.5	--	01	--
Thalictrum occidentale	.5	--	25	01	--	--	--	--	--	03
Vaccinium caespitosum	--	--	--	05	10	--	--	10	--	05
Vaccinium membranaceum	.5	--	02	--	--	--	--	--	--	03
Valeriana sitchensis	.5	03	15	--	.5	--	07	--	--	03
Veratrum eschscholtzii	01	--	10	--	--	--	03	--	--	02
EPIGEOID LAYER										
Barbilophozia lycopodioides	--	--	05	10	--	.5	--	05	05	02
Cladonia spp.	02	.5	.5	.5	01	.5	04	.5	03	.5
Dicranum brevifolium	--	--	--	10	--	.5	--	--	01	--
Dicranum scoparium	--	--	--	10	--	10	05	15	05	--
Drepanocladus uncinatus	35	--	.5	--	--	.5	10	--	--	--
Hylocomium splendens	--	--	10	--	--	30	--	--	--	15
Peltigera aphthosa	--	--	--	--	--	02	--	.5	02	--
Peltigera rufescens	--	.5	--	.5	.5	.5	--	--	--	--
Pleurozium schreberi	--	--	05	--	--	20	--	--	--	20
EPIPHYTES										
Bryoria fuscescens	--	--	.5	.5	--	--	--	.5	--	--
Lotharia vulpina	--	--	--	.5	--	--	--	.5	--	--
Parmeliopsis hyperopta	--	--	.5	--	.5	--	--	--	--	--
Usnea spp.	--	--	--	.5	--	--	--	.5	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Stands of O9 are generally 100 to 300 years old and are mature successionally.

The O9 v.t. is differentiated from O10 by being moister and dominated by herbs rather than dwarf shrubs. The H16 v.t. has many species in common with O9, but lacks tree cover. Stands which intergrade with O10 or H16 occur.

Other Studies: Similar types have been described by Baig (1972) for the Alberta Rockies (*Pinus albicaulis-Abies-Picea/Valeriana sitchensis*), Trottier and Scotter (1973) for Banff (*Picea-Abies/Trollius albiflorus/Carex* spp.), and Habeck (1969) described a similar type for Logan Pass, Glacier National Park, Montana.

O10: ***Picea engelmannii-Abies lasiocarpa/Phyllodoce glanduliflora-Cassiope mertensiana***

(Engelmann spruce-subalpine fir/heather)

Environment: The O10 v.t. open forests occur on mesic Upper Subalpine (1830-2150 m J; 1920-2400 m B), level to steeply sloping sites of predominantly northerly aspect. Soils are well drained Dystric and Eutric Brunisols, and Orthic Humo-Ferric Podzols developed primarily on morainal and colluvial landforms and to a lesser extent on fluvial, glaciofluvial, and residual landforms.

Table 52 Stands representing the Engelmann spruce-subalpine fir / heather (010) v.t.

	AW	IC	JC	JD	JE	JN	KS	LC	PA	SJ
	70	60	60	80	90	80	60	91	91	70
	83	95	28	91	65	29	61	49	25	60
TREE LAYER										
Abies lasiocarpa	.5	19	01	--	.5	03	07	08	05	05
Picea engelmannii	14	10	15	09	05	14	06	--	--	04
TALL SHRUB LAYER										
Abies lasiocarpa	20	20	01	10	15	--	03	12	.5	02
Picea engelmannii	02	05	02	05	10	01	03	03	.5	02
SHRUB LAYER										
Abies lasiocarpa	36	25	01	.5	15	07	03	15	.5	--
Picea engelmannii	.5	05	01	01	05	04	.5	--	--	--
Salix barrattiana	--	--	--	--	--	--	.5	--	05	--
Salix glauca	--	--	--	--	45	--	03	08	--	--
Salix vestita	--	02	--	--	--	05	--	10	--	--
Vaccinium membranaceum	--	03	--	--	--	--	--	--	--	--
HERB-DWARF SHRUB LAYER										
Antennaria lanata	--	--	.5	15	--	01	06	--	.5	--
Arnica cordifolia	--	--	--	--	--	03	03	--	--	--
Arnica latifolia	--	01	--	--	--	--	12	04	--	--
Artemisia norvegica	--	--	--	--	--	02	--	07	05	08
Cassiope mertensiana	--	30	--	--	45	02	--	--	--	15
Cassiope tetragona	03	--	03	05	--	--	--	--	10	--
Dryas octopetala	--	--	--	01	--	--	.5	05	--	04
Epilobium angustifolium	--	--	.5	--	--	--	03	--	--	01
Erigeron peregrinus	--	01	.5	05	--	--	08	03	--	03
Hedysarum alpinum	--	--	--	--	--	--	--	08	--	--
Luetkea pectinata	--	--	--	--	--	03	--	--	--	--
Parnassia fimbriata	--	--	--	--	--	01	--	--	--	--
Pedicularis bracteosa	--	.5	.5	--	--	07	08	--	.5	07
Phyllodoce empetriformis	37	--	60	--	--	03	02	--	--	05
Phyllodoce glanduliflora	--	30	--	45	20	17	20	10	55	20
Potentilla diversifolia	--	--	--	.5	--	--	.5	01	--	--
Pyrola secunda	--	--	--	--	--	03	--	--	--	--
Salix arctica	--	--	--	--	--	--	05	--	05	--
Vaccinium scoparium	03	05	10	05	05	50	15	--	05	15
Valeriana sitchensis	--	--	--	--	--	03	--	--	--	--
Zygadenus elegans	--	--	--	.5	--	--	--	03	--	.5
Equisetum scirpoides	--	--	--	--	--	04	.5	--	--	--
Lycopodium annotinum	--	--	--	--	--	--	05	--	.5	--
Selaginella densa	--	--	--	--	--	--	06	--	--	.5
EPIGEOID LAYER										
Cetraria ericetorum	--	--	--	--	.5	.5	--	--	--	.5
Cetraria islandica	--	--	--	.5	--	.5	06	--	05	.5
Cladonia mitis	03	--	--	--	01	--	--	--	10	--
Cladonia cariosa	--	--	--	--	--	.5	--	07	--	--
Cladonia ecmocyna	--	--	--	--	.5	02	.5	--	--	03
Cladonia gracilis	--	--	--	--	--	02	--	--	01	.5
Cladonia pyxidata	--	--	--	.5	--	--	--	--	08	--
Cladonia squamules	--	--	--	05	--	--	--	--	--	--
Cladonia spp.	02	02	.5	--	--	--	10	--	--	--
Dicranum fuscescens	--	--	--	--	--	--	15	--	--	--
Dicranum muehlenbeckii	--	--	20	35	--	--	--	--	--	--
Dicranum scoparium	--	--	25	--	20	--	15	--	10	20
Dicranum spp.	03	05	--	--	--	--	10	--	--	--
Drepanocladus uncinatus	--	--	--	--	--	--	03	--	03	--
Hylocomium splendens	75	--	--	--	--	--	--	--	10	--
Peltigera aphthosa	06	--	.5	.5	--	02	--	--	--	.5
Peltigera canina	--	--	--	--	.5	--	01	--	--	--
Pleurozium schreberi	18	--	--	--	--	--	15	--	--	--
Polia spp.	--	--	--	--	--	--	--	--	03	--
Polytrichum juniperinum	--	--	--	--	01	--	--	05	--	--
Rhizocarpon geographicum	--	--	--	--	--	.5	--	--	--	.5
Barbilophozia hatcheri	--	--	--	--	--	.5	--	--	05	.5
Barbilophozia lycopodioides	--	--	--	--	.5	.5	01	--	05	--
Barbilophozia spp.	--	25	--	--	--	--	--	--	--	--
EPIPHYTES										
Cetraria pinastri	--	--	--	--	.5	.5	.5	--	--	--
Parmeliopsis ambigua	--	--	--	--	.5	.5	--	--	--	.5
Alectoria spp.	.5	--	.5	--	.5	--	--	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: *Picea engelmannii* (<20%) is the dominant tree and *Abies lasiocarpa* (<20%) is often codominant (Table 52). Total tree cover is generally <20% (Plate 42). The shrub layer has low to high cover (10-55%) and is dominated by *Abies lasiocarpa* (10-50%) and *Picea engelmannii* (5-10%) regeneration. The herb-dwarf shrub layer has moderate to high cover (30-85%) due mainly to the high cover of the heaths, *Phyllodoce glanduliflora* and *Phyllodoce empetriformis* (5-50%), *Cassiope mertensiana* (10-50%), and *Vaccinium scoparium* (5-25%). Also characteristic are *Antennaria lanata* (<10%) and *Pedicularis bracteosa* (<5%). The bryoid layer has low to high cover (5-75%) and is dominated by *Barbilophozia lycopodioides* (5-50%) and *Dicranum scoparium* (5-25%). *Hylocomium splendens* and *Pleurozium schreberi* are locally abundant. Common lichens are *Peltigera aphthosa* (<5%), *Cladonia ecmocyna* (<5%), and *Cetraria islandica* (<5%) with total lichen cover 5 to 15%.

The O10 v.t. is successionally mature with most stands 200 to 400 years old.

The O10 v.t. is distinguished from C34 by having a more open physiognomy, less abundant *Hylocomium splendens* and *Pleurozium schreberi*, and by generally higher elevations. The O10 v.t. is distinguished from O9 by being drier and having much lower cover of *Valeriana sitchensis* and *Erigeron peregrinus*. Stands with abundant *Larix lyallii* may be transitional to C23 at the upper elevational limit of O10. At high elevations where 50% or more of an Ecosite is without trees and vegetation is heath dominated, these sites have been described as L5 > O10 such as on the Egypt 4, Larch Valley 2, and Peyto Lake 4 Ecosites.

Other Studies: In Jasper, La Roi (1975, *Picea engelmannii/Phyllodoce* types) and Eeil (1966) have described similar types. In other parts of Alberta, similar types have been described by Bai; (1972, *Abies-Picea/Phyllodoce*), Kirby and Ogilvie (1969, Krummholz/*Vaccinium scoparium*), Ogilvie (1976, *Phyllodoce-Vaccinium scoparium*), and Johnson (1975, *Picea engelmannii-Phyllodoce glanduliflora*). In British Columbia, McLean (1970, *Abies lasiocarpa-Vaccinium scoparium*) and Kuchar (1978, alpine fir forest in part) have described similar types.

O11: *Picea* spp./*Ledum groenlandicum/Tomenthypnum nitens*

(spruce/Labrador tea/brown moss)

Environment: The O11 v.t. occurs on hygric to subhydric, Montane to Lower Subalpine sites (1330-1770 m) on nearly level to very gentle slopes of various aspect in Banff and Jasper. The soils are poorly to very poorly drained Rego Gleysols and Terric Mesisols on glacial and glaciolacustrine landforms. Fluvial and organic veneers are common.

Table 53 Stands representing the spruce / Labrador tea / brown moss (011) v.t.

	AW 71 03	IC 50 93	IC 61 19	IC 90 13	IC 90 27	JD 90 05	JD 90 31	PA 70 17	SJ 80 88	SJ 90 29
TREE LAYER										
Picea glauca	07	01	02	--	--	--	--	07	01	--
Picea mariana	--	10	08	10	10	15	10	--	02	.5
Pinus contorta	--	--	--	--	.5	.5	--	.5	02	--
TALL SHRUB LAYER										
Picea glauca	03	--	--	--	--	--	--	01	--	--
Picea mariana	--	--	05	02	03	02	07	--	04	03
Pinus contorta	--	02	01	--	.5	--	--	--	03	--
SHRUB LAYER										
Betula glandulosa	20	.5	02	15	12	30	.5	10	08	05
Ledum groenlandicum	05	35	01	--	12	.5	25	07	18	02
Picea glauca	03	--	--	--	--	--	--	01	--	--
Picea mariana	--	--	--	03	02	.5	03	--	04	02
Potentilla fruticosa	05	--	08	--	--	10	--	03	.5	04
Salix glauca	--	05	--	--	01	05	01	--	--	06
Salix myrtillifolia	--	--	03	10	03	20	10	--	05	15
HERB-DWARF SHRUB LAYER										
Arctostaphylos rubra	--	.5	01	--	01	15	10	.5	10	--
Carex aquatilis	25	--	--	23	02	--	60	10	--	60
Carex capillaris	--	--	.5	--	--	--	--	01	--	--
Carex concinna	--	--	--	--	--	--	05	01	--	--
Carex gynocrates	--	--	--	--	--	--	02	--	--	05
Carex scirpoidea	10	--	10	--	--	--	--	--	--	--
Carex vaginata	02	--	--	02	08	30	05	--	05	--
Deschampsia cespitosa	02	--	.5	--	--	--	05	--	--	--
Empetrum nigrum	05	05	--	--	--	--	--	02	--	--
Geocaulon lividum	--	.5	--	--	--	--	--	--	--	--
Oxycoccus microcarpus	--	.5	.5	--	.5	--	--	02	--	--
Pyrola asarifolia	--	--	.5	--	--	.5	--	--	01	--
Rubus arcuilis	--	--	--	.5	--	.5	--	--	--	01
Scirpus cespitosus	--	--	05	--	--	--	--	01	--	--
Tofieldia pusilla	--	.5	--	--	--	--	--	--	07	--
Vaccinium vitis-idaea	01	05	01	--	02	05	--	03	04	03
Equisetum arvense	--	03	.5	--	--	--	05	--	06	--
Equisetum scirpoides	--	.5	--	--	02	--	05	--	--	--
Equisetum variegatum	--	.3	03	--	--	--	--	.5	03	--
BRYOID LAYER										
Aulacomnium palustre	03	02	--	20	05	--	65	.5	03	02
Cladonia mitis	08	05	.5	--	--	--	05	--	--	04	--
Drepanocladus revolvens	--	--	--	--	10	.5	--	--	--	--	05
Hylocomium splendens	--	45	04	--	05	05	05	.5	15	02
Peltigera aphthosa	03	01	--	--	.5	--	.5	--	01	.5
Pleurozium schreberi	--	40	--	--	02	--	--	01	--	--
Sphagnum fuscum	--	--	--	--	70	--	--	60	--	02
Sphagnum warnstorfii	--	01	--	01	--	--	--	07	10	05
Tomenthypnum nitens	64	--	35	35	05	01	30	25	70	15
EPIPHYTES										
Alectoria spp.	--	--	--	--	--	--	.5	.5	.5	--	--
Ramalina sinensis	--	--	--	--	--	--	--	.5	--	--	.5	--
Usnea cavernosa	--	--	--	--	--	--	--	.5	--	--	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: The tree layer is open with a total cover of 5 to 20% (Table 53, Plate 43). The dominant tree in Jasper and northern Banff is *Picea mariana* (5-15%). *Picea mariana* does not occur south of Bow Pass in Banff, thus in southern Banff the dominant is *Picea glauca* or a *Picea glauca* x *Picea engelmannii* hybrid. The shrub layer is moderately dense (20-50%) and is dominated by *Ledum groenlandicum* (10-15%) and *Betula glandulosa* (5-15%), with lesser amounts of *Potentilla fruticosa* (3%) and *Salix glauca* (3%). *Salix myrtillifolia* (5%) is a common component in Jasper. The herb-dwarf shrub layer is dense (40-80%) and species-rich. Common species are *Carex aquatilis*

(10-20%), *Carex vaginata* (1-3%), *Equisetum arvense* (5-10%), and *Vaccinium vitis-idaea* (1-2%). Species with low cover but high frequency include *Carex capillaris*, *Equisetum scirpoides*, and *Oxycoccus microcarpus*. *Arctostaphylos rubra* (1-3%) occurs in many Jasper stands and *Empetrum nigrum* (2-5%) occurs in many Banff stands. The hummocky ground surface has a nearly complete cover of mosses. Hollows and the lower portions of hummocks are occupied by *Tomenthypnum nitens* (20-25%), *Aulacomnium palustre* (5-10%), and *Sphagnum warnstorfii* (3-5%). Hummock tops and other drier sites contain *Sphagnum fuscum* (5-15%), *Hylocomium splendens* (5-20%), *Cladonia mitis* (1-3%), and *Peltigero aphthosa* (<1%) .

Stands of the O11 v.t. are 100 to 250 years old and are mature successionally. *Picea* spp. regeneration is present in nearly all stands.

The O11 v.t. is distinguished from O6 by having *Ledum groenlandicum* the dominant shrub rather than *Salix* spp.. The O11 v.t. also occurs in both Montane and Lower Subalpine, while O6 occurs only in Lower Subalpine.

Other Studies: Similar types have been described by Raup (1947) for the southwestern Northwest Territories (muskeg forest), Kirby and Ogilvie (1969, Ogilvie 1963, *Picea/Sphagnum-Ledum*), and Jacques and Legge (1974, *Picea/Sphagnum-Ledum*) for the Kananaskis area of Alberta. In Jasper, Laidlaw (1971) described a similar type *(Picea mariana/Tomenthypnum*) as did La Roi (1975, *Picea mariana/Ledum groenlandicum/Equisetum arvense-Carex* spp.)

O12: *Picea engelmannii-Abies lasiocarpa/Salix vestita/Arctostaphylos rubra*

(Engelmann spruce-subalpine fir/rock willow/ alpine bearberry)

Environment: The O12 v.t. occurs on mesic to subhygric, usually Upper Subalpine (1500-2100 m), moderate to steep, north facing slopes primarily in Jasper. The soils are generally well to moderately well drained Eutric Brunisols and Regosols developed on colluvial, fluvial and morainal landforms.

Vegetation: *Picea engelmannii* is the predominant canopy tree (Plate 44) with 2 to 30% cover, but generally <15% (Table). *Abies lasiocarpa* is present in about 50% of the stands sampled with cover <10%. *Pinus contorta* and *Pinus albicaulis* occur occasionally. The shrub layer is usually dense (30-70%) and is dominated by *Salix vestita* (10-35%) and *Abies lasiocarpa* (3-15%). The herb-dwarf shrub layer is moderately well developed (20-50%) and is dominated by *Arctostaphylos rubra* (3-15%) and *Dryas octopetala* (3-10%). *Cassiope tetragona* and *Linnaea borealis* may attain cover of 40% and 30% respectively but may be absent. The bryoid layer is generally moderately well developed (15-45%) though few species are abundant in a large proportion of O12 stands. The pre-

Table 54 Stands representing the Engelmann spruce-subalpine fir / rock willow / alpine bearberry(012) v.t.

	AW	CC	IC	IC	JC	JC	JC	JB	BJ	BJ
	70	60	80	90	60	80	80	90	80	91
	63	67	06	24	64	25	26	74	07	02
TREE LAYER										
Abies lasiocarpa	03	--	.5	09	10	--	--	02	--	--
Picea engelmannii	22	12	23	06	30	15	05	05	01	08
Pinus contorta	03	10	--	--	--	--	--	--	12	--
TALL SHRUB LAYER										
Abies lasiocarpa	.5	--	.5	01	08	--	--	02	--	--
Picea engelmannii	03	--	.5	04	05	02	01	--	02	05
SHRUB LAYER										
Abies lasiocarpa	08	--	--	02	15	20	01	15	03	05
Betula glandulosa	--	--	--	--	--	--	.5	--	--	03
Juniperus communis	02	01	--	02	--	--	--	03	04	.5
Ledum groenlandicum	--	05	--	--	01	--	--	--	.5	.5
Picea engelmannii	02	07	.5	02	08	--	--	.5	05	04
Pinus contorta	--	05	--	--	--	--	--	--	10	--
Salix glauca	.5	--	--	10	--	05	01	--	02	01
Salix vestita	30	30	35	20	12	35	03	15	15	23
HERB-DWARF SHRUB LAYER										
Abies lasiocarpa	--	--	--	--	--	--	--	--	--	11
Anemone parviflora	01	--	--	--	.5	01	--	--	01	--
Arctostaphylos rubra	03	15	--	--	01	04	17	01	08	04
Artemisia norvegica	--	--	--	08	--	--	--	--	04	--
Carex concinna	01	--	--	--	.5	.5	--	--	--	01
Carex concinnoides	--	--	01	--	--	--	01	--	--	--
Carex scirpoides	--	10	--	--	--	--	--	--	--	--
Carex vaginata	--	--	--	--	--	--	02	--	--	--
Carex spp.	--	05	--	--	--	--	--	--	01	--
Cassiope tetragona	.5	40	.5	--	.5	12	--	--	--	--
Dryas octopetala	--	08	01	02	03	01	--	--	05	--
Elymus innovatus	04	03	--	02	02	01	--	--	--	--
Empetrum nigrum	--	04	--	--	--	--	--	--	--	15
Epilobium angustifolium	--	--	--	01	--	--	--	.5	--	--
Erigeron peregrinus	--	--	--	02	--	01	--	--	--	--
Hedysarum alpinum	--	--	01	.5	--	--	--	--	--	--
Linnaea borealis	30	--	--	01	03	--	--	.5	05	.5
Parnassia fimbriata	.5	--	--	--	--	--	--	--	01	--
Pedicularis bracteosa	02	01	.5	01	--	.5	--	--	--	--
Pyrola asarifolia	.5	--	--	--	--	--	.5	--	01	--
Pyrola secunda	--	.5	01	.5	--	--	--	.5	.5	.5
Salix myrtillifolia	--	--	--	--	--	--	08	--	--	--
Salix vestita	--	--	--	--	--	--	02	02	--	--
Vaccinium caespitosum	--	.5	--	--	--	--	--	--	--	--
Vaccinium membranaceum	--	--	--	--	--	--	--	--	01	.5
Vaccinium scoparium	--	03	--	--	.5	--	--	--	--	--
Vaccinium vitis-idaea	--	.5	--	--	--	--	--	--	--	02
Zygadenus elegans	01	01	--	--	--	--	--	--	.5	--
Equisetum scirpoides	--	--	01	02	--	02	--	--	--	--
BRYOID LAYER										
Brachythecium groenlandicum	--	--	--	--	--	--	--	--	03	--
Cladonia mitis	--	--	--	--	--	--	01	--	02	--	02
Cladonia cornuta	--	--	--	--	--	--	--	.5	--	.5	.5
Cladonia pyxidata	--	--	.5	--	--	--	01	.5	.5	--
Cladonia spp.	01	--	--	.5	01	--	.5	--	.5	.5
Dicranum acutifolium	--	--	--	--	--	--	05	--	--	--	02
Dicranum brevifolium	--	--	--	--	--	--	--	03	15	--	--
Dicranum muehlenbechii	--	--	--	--	--	--	05	--	--	--	--
Dicranum scoparium	--	--	--	05	02	10	--	--	--	01	--
Dicranum spp.	--	04	--	--	--	--	--	--	--	--	--
Distichium capillaceum	--	--	--	.5	--	--	--	--	--	02	.5
Ditrichum flexicaule	--	--	--	.5	--	.5	--	02	.5	--	--
Drepanocladus uncinatus	20	--	--	.5	01	--	--	--	--	.5	02
Drepanocladus spp.	--	--	--	--	--	--	05	--	--	--	--
Encalypta affinis	--	--	--	.5	--	--	--	--	--	--	--
Hylocomium splendens	--	--	--	.5	--	15	50	--	10	02	60
Hypnum bambergeri	--	--	--	--	--	--	--	03	--	--	--
Hypnum revolutum	--	--	--	--	--	--	--	--	.5	02	--
Peltigera aphthosa	02	--	--	--	--	02	01	--	.5	03	.5
Peltigera canina	--	--	--	--	--	--	--	--	.5	01	--
Peltigera rufescens	--	--	--	.5	.5	--	--	--	--	.5	--
Pleurozium ochreberi	--	--	--	--	--	--	--	--	--	--	10
Thuidium abietinum	--	--	--	--	01	--	--	--	.5	.5	--
Tomenthypnum nitens	--	--	--	--	--	--	--	30	--	--	--
Tortella tortuosa	--	--	--	--	--	--	--	02	--	--	--
Tortula norvegica	02	--	.5	01	--	--	--	--	--	--	--
Barbilophozia lycopodioides	--	--	.5	--	--	--	--	--	--	--	01
EPIPHYTES										
Alectoria spp.	--	--	--	--	--	.5	--	--	--	--	.5
Cetraria pinastri	--	--	--	.5	--	--	--	--	--	.5	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

dominant mosses are *Hylocomium splendens* and *Dicranum scoparium*. Epiphytes are generally sparse.

Successionally O12 is mature, its open physiognomy being maintained by sporadic colluviation.

The O12 v.t. is distinguished from O14 by being drier and less herb-rich and by the presence of *Dryas octopetala* in O12. Sparsely treed stands may be transitional to S2.

Other Studies: No similar type has been described.

O14: *Picea engelmannii-Abies lasiocarpa/Salix vestita/Pedicularis bracteosa*

(Engelmann spruce-subalpine fir/rock willow/bracted lousewort)

Environment: The O14 v.t. occurs on subhygric to hygric, usually Upper Subalpine (1500-2140 m), moderate to steep, north facing slopes, primarily in Banff. The soils are imperfectly to poorly drained Gleysols developed on morainal and to a lesser extent on fluvial landforms.

Vegetation: *Picea engelmannii* is the dominant tree with 5 to 75% cover but generally <20% (Plate 45), though closed forests occur in nearly one-half of the stands sampled (Table 55). *Abies lasiocarpa* is usually present with cover <10%. *Pinus contorta* occurs sporadically with cover <10%. The shrub layer is usually dense (15-95%) and is dominated by *Salix vestita* (5-50%) and *Abies lasiocarpa* (10-20%). The herb-dwarf shrub layer is lush with a cover of 40 to 70% and is dominated by *Pedicularis bracteosa* (1-5%), *Polygonum viviparum* (<3%), *Erigeron peregrinus* (1-3%), *Vaccinium scoparium* (2-15%), and *Anemone parviflora* (<3%). *Potentilla fruticosa* (3-8%), *Empetrum nigrum* (2-8%), and *Stenanthium occidentale* (1-5%) occur in over one-half of the sampled stands. The bryoid layer is moderately well developed (40-70%) and is dominated by *Pleurozium schreberi* (5-15%), *Barbilophozia* spp. (3-10%), and *Aulacomnium palustre* (10%). *Peltigera aphthosa* is the most abundant lichen (<5%).

The O14 v.t. is mature successionally.

The O14 v.t. is distinguished from O12 by being wetter and having greater cover of trees, herbs, dwarf shrubs, and mosses. Species richness is greater in O14.

Other Studies: Similar types were described by Baig (1972) for the Alberta Rocky Mountains *(Abies-Picea/Salix vestita)* and by Kondla (1978) for the Kananaskis area of Alberta (spruce/willow).

Table 55 Stands representing the Engelmann spruce-subalpine fir / rock willow / bracted lousewort (O14) v.t.

	AB 30 65	JB 70 24	RS 50 88	RS 80 87	RB 51 30	RS 51 35	RS 60 46	RS 60 47	RS 60 60	PA 71 38
TREE LAYER										
Abies lasiocarpa	01	00	05	05	10	05	--	--	15	04
Picea engelmannii	15	15	25	33	25	30	10	20	35	06
Pinus contorta	--	--	10	15	--	--	05	02	--	--
TALL SHRUB LAYER										
Abies lasiocarpa	03	15	10	10	00	05	02	--	10	05
Picea engelmannii	01	.5	15	00	10	03	05	10	05	.5
Pinus contorta	--	--	--	00	--	--	03	--	--	--
SHRUB LAYER										
Abies lasiocarpa	16	05	10	10	15	10	02	04	05	.5
Betula glandulosa	--	--	06	12	--	--	--	--	05	--
Betula pumila	--	--	--	--	--	--	05	05	--	--
Juniperus communis	--	--	--	.5	--	--	.5	--	.5	--
Ledum groenlandicum	--	--	06	03	03	--	01	02	03	--
Lonicera involucrata	--	--	01	02	--	--	--	--	.5	--
Menziesia glabella	--	--	08	02	--	--	01	01	--	--
Picea engelmannii	02	.5	06	06	--	.5	06	08	03	--
Potentilla fruticosa	--	--	02	--	.5	.5	03	03	03	10
Salix barrattiana	--	--	02	--	--	06	10	--	--	--
Salix candida	--	--	--	01	03	--	--	--	--	--
Salix farrae	--	--	04	15	--	--	08	--	--	--
Salix glauca	--	--	02	--	05	.5	--	01	.5	--
Salix vestita	23	80	15	20	20	35	20	25	15	25
Vaccinium membranaceum	--	--	--	--	05	--	--	--	--	--
HERB-DWARF SHRUB LAYER										
Anemone parviflora	--	.5	03	--	--	03	01	01	.5	03
Aquilegia flavescens	--	.5	.5	--	.5	06	.5	.5	.5	--
Arctostaphylos rubra	--	--	--	04	--	--	10	06	--	--
Arnica cordifolia	--	--	--	--	--	--	--	--	05	--
Arnica latifolia	--	05	--	--	--	--	--	--	01	--
Aster ciliolatus	--	02	01	01	--	--	--	--	--	--
Carex capillaris	--	--	06	--	02	--	10	04	.5	--
Carex concinna	--	--	.5	--	--	05	--	--	--	--
Carex media	01	--	--	--	03	02	--	.5	.5	--
Carex scirpoidea	--	--	08	06	--	02	20	12	--	15
Carex vaginata	--	--	12	20	15	--	10	10	03	--
Cassiope mertensiana	--	03	.5	--	--	--	--	--	--	--
Cassiope tetragona	42	15	--	.5	--	--	--	.5	--	--
Castilleja occidentalis	--	--	--	--	--	.5	.5	--	--	--
Elymus innovatus	--	.5	--	--	--	--	--	04	--	--
Empetrum nigrum	01	--	03	08	05	--	--	03	03	--
Erigeron peregrinus	--	--	03	03	02	03	03	06	15	05
Erythronium grandiflorum	--	--	--	--	--	.5	--	--	01	--
Fragaria virginiana	--	--	.5	--	--	02	--	.5	.5	.5
Gaultheria humifusa	--	--	--	--	02	--	--	--	--	--
Kalmia polifolia	--	--	02	02	01	--	--	--	--	--
Linnaea borealis	--	--	.5	.5	--	--	01	02	--	--
Parnassia fimbriata	--	02	02	--	--	--	--	--	01	05
Parnassia palustris	--	--	--	--	--	.5	08	05	--	--
Pedicularis bracteosa	06	35	02	02	02	08	01	02	03	--
Pedicularis groenlandica	--	--	--	--	--	--	.5	--	--	01
Petasites vitifolius	--	--	--	--	--	--	--	--	03	--
Polygonum viviparum	.5	.5	02	02	.5	03	02	.5	.5	01
Phyllodoce glanduliflora	--	--	04	01	20	--	--	--	03	02
Pyrola asarifolia	.5	--	01	.5	--	.5	.5	.5	--	--
Pyrola secunda	--	.5	.5	--	.5	--	--	--	--	--
Senecio lugens	02	--	--	--	--	--	--	--	--	--
Senecio triangularis	--	--	.5	02	.5	--	--	--	01	05
Solidago multiradiata	--	--	.5	.5	--	.5	--	--	--	.5
Stenanthium occidentale	--	--	06	03	--	05	--	01	02	--
Thalictrum occidentale	--	--	--	--	--	--	--	--	.5	01
Trollius albiflorus	--	--	--	--	03	08	06	--	10	05
Vaccinium scoparium	13	.5	15	05	10	12	--	04	15	--
Vaccinium vitis-idaea	--	--	03	04	--	--	--	--	--	--
Veratrum eschscholtzii	--	--	--	--	--	--	--	--	05	--
Zygadenus elegans	--	--	--	--	--	--	08	--	--	01
Equisetum arvense	--	--	01	01	03	--	--	--	02	--
Equisetum hyemale	--	--	--	--	--	--	05	--	--	--
Equisetum variegatum	--	--	.5	02	--	.5	.5	.5	--	--
Oxycoccus microcarpus	--	--	--	01	--	--	--	--	--	--
Phyllodoce empetriformis	02	--	--	--	--	--	--	--	--	--
BRYOID LAYER										
Aulacomnium palustre	--	--	15	03	10	--	20	15	20	--
Bryum pseudotriquetrum	--	--	--	--	.5	--	05	.5	--	--
Campylium stellatum	--	--	02	--	.5	--	30	40	--	--
Cladonia ecmocyna	--	--	02	--	03	.5	--	--	--	--
Dicranum acutifolium	--	--	02	06	--	10	--	--	--	--
Dicranum muehlenbeckii	10	--	--	.5	--	--	--	--	--	--
Dicranum scoparium	--	.5	--	--	60	--	--	02	--	08
Ditrichum flexicaule	--	--	--	--	--	10	--	.5	--	--
Drepanocladus revolvens	--	--	--	03	05	--	--	--	--	--
Drepanocladus uncinatus	--	.5	--	--	--	03	30	15	08	04
Hylocomium splendens	30	--	--	--	15	--	--	05	05	25
Peltigera aphthosa	02	.5	03	05	.5	--	--	--	--	02
Pleurozium schreberi	15	--	15	20	10	--	05	05	15	.5
Sphagnum warnstorfii	--	--	04	04	.3	--	--	--	--	--
Tomenthypnum nitens	--	--	02	--	.5	--	10	--	--	--
Barbilophozia hatcheri	10	--	10	10	10	10	--	--	30	--
Barbilophozia lycopodioides	--	.5	.5	.5	10	05	--	--	--	03
EPIPHYTES										
Alectoria spp.	--	.5	--	.5	.5	.5	.5	.5	--	--
Letharia vulpina	--	--	--	--	--	.5	.5	--	--	.5
Parmelia spp.	--	--	--	--	.5	.5	.5	--	--	--
Parmeliopsis spp.	--	--	--	--	.5	--	--	.5	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

O16: ***Betula papyrifera/Betula occidentalis/ Arctostaphylos uva-ursi***

(paper birch/bearberry)

Environment: Open birch forests of the O16 v.t. occur on subxeric, Montane (1250 m) moderately steep, southerly aspects in the east gate area of Jasper. Soils are predominantly rapidly drained Cumulic Regosols on eolian landforms. Loess [illegible]ill being deposited on these sites.

Vegetation: Although tree cover is sparse (<10%) (Table 56), individual *Betula papyrifera* trees may attain heights of 17 m and dbh's of 20 cm (Plate 46). The shrub stratum which has moderate cover (20%) is dominated by *Betula occidentalis* (10%) with lesser amounts of *Juniperus communis* (3%) and *Potentilla fruticosa* (2%). The herb-dwarf shrub layer has cover of 45%, dominated by *Arctostaphylos uva-ursi* (40%) with lesser cover of *Elymus innovatus* (3%), *Aster conspicuus* (2%), *Carex concinna* (2%), *Zygadenus elegans* (1%), *Anemone multifida* (1%), and *Carex scirpoidea* (1%). The bryoid layer has 1% cover.

Table 56 Stand representing the paper birch / bearberry (016) v.t.

	IC
	70
	02
TREE LAYER	
Betula papyrifera	06
TALL SHRUB LAYER	
Betula occidentalis	09
Betula papyrifera	01
Picea glauca	.5
Populus tremuloides	.5
SHRUB LAYER	
Juniperus communis	03
Potentilla fruticosa	02
HERB-DWARF SHRUB LAYER	
Androsace chamaejasme	.5
Anemone multifida	01
Arctostaphylos uva-ursi	40
Aster conspicuus	02
Carex concinna	02
Carex scirpoidea	01
Elymus innovatus	03
Erigeron caespitosus	.5
Taraxacum officinale	.5
Zygadenus elegans	01

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Successionally O16 is intermediate to mature with the possibility that *Picea glauca* cover may increase since sporadic *Picea glauca* regeneration occurs.

The O16 v.t. is a minor associate in Talbot 3 (TA3), its occurrence being greater than the one sampled stand indicates. This v.t. is unique in being the only one that has *Betula papyrifera* and *Betula occidentalis* as dominants, these species being absent or very uncommon in most of the Banff - Jasper area. Stands with less *Betula* spp. and more *Picea glauca* are transitional to O17.

Other Studies: No similar type has been described by other workers.

O17: ***Picea glauca/Juniperus communis/Arctostaphylos uva-ursi***

(white spruce/juniper/bearberry)

Environment: The O17 v.t. occurs predominantly on subxeric to mesic, Lower Subalpine sites (1550-2030 m) on various slopes of southerly and westerly aspect. The soils are rapidly to well drained Orthic Eutric Brunisols and Orthic Regosols on colluvial, fluvial, and morainal landforms, and to a lesser extent on eolian landforms.

Table 57 Stands representing the white spruce / juniper / bearberry (017) v.t.

	IC	JR	JR	JR	JH	KS	LC	PA	SJ	SJ
	70	80	80	81	80	60	90	80	70	90
	27	09	40	38	61	39	43	43	47	56
TREE LAYER										
Picea engelmannii	--	--	08	10	15	18	--	10	--	--
Picea glauca	17	10	--	--	--	--	10	--	13	08
Pinus contorta	--	05	--	02	--	04	05	--	02	03
Populus tremuloides	.5	.5	--	--	--	--	--	--	--	--
TALL SHRUB LAYER										
Picea engelmannii	--	--	01	01	05	03	--	.5	--	--
Picea glauca	02	--	--	--	--	--	--	--	10	01
SHRUB LAYER										
Juniperus communis	05	01	08	05	03	35	20	25	04	02
Potentilla fruticosa	--	--	.5	--	02	--	05	01	.5	--
Rosa acicularis	05	--	--	--	.5	.5	01	--	05	--
Salix glauca	--	.5	--	07	15	--	--	--	--	03
Shepherdia canadensis	20	12	.5	15	--	02	10	03	07	23
HERB-DWARF SHRUB LAYER										
Achillea millefolium	--	.5	--	--	--	--	02	--	.5	--
Anemone multifida	--	--	--	.5	--	--	01	--	.5	--
Arctostaphylos uva-ursi	15	03	05	25	01	12	30	20	04	02
Aster conspicuus	--	--	--	--	--	--	12	03	--	05
Carex concinna	03	--	--	--	--	--	01	--	.5	01
Elymus innovatus	10	25	.5	06	13	10	15	05	04	12
Epilobium angustifolium	--	.5	--	.5	--	--	02	--	--	--
Fragaria virginiana	.5	.5	--	--	--	.5	05	--	--	02
Hedysarum alpinum	.5	--	--	--	--	--	--	--	--	01
Hedysarum sulphurescens	--	01	01	02	--	--	--	15	--	--
Juniperus horizontalis	.5	--	02	--	02	--	01	03	30	--
Linnaea borealis	--	--	--	--	04	04	--	--	08	11
Solidago multiradiata	--	.5	--	.5	01	--	--	.5	--	--
Zygadenus elegans	--	--	--	.5	02	--	05	--	.5	01
BRYOID LAYER										
Cladonia gonecha	--	01	--	--	.5	.5	--	--	--	.5
Ditrichum flexicaule	--	.5	--	--	.5	--	--	.5	.5	--
Hylocomium splendens	--	05	--	--	05	04	--	25	10	01
Hypnum revolutum	--	.5	--	.5	.5	--	--	.5	--	--
Peltigera aphthosa	--	--	--	--	--	.5	--	10	--	.5
Peltigera canina	--	05	--	--	--	01	--	--	--	--
Peltigera rufescens	--	.5	--	--	.5	.5	--	--	.5	.5
Pleurozium schreberi	--	--	--	--	--	10	--	20	--	.5
Stereocaulon tomentosum	--	.5	--	--	--	--	--	.5	--	.5
Thuidium abietinum	02	.5	--	--	07	--	--	--	.5	--
EPIPHYTES										
Cetraria pinastri	--	--	--	--	.5	.5	--	--	.5	.5
Hypogymnia austerodes	--	--	--	.5	--	.5	--	--	.5	--
Letharia vulpina	--	.5	--	.5	--	--	--	--	--	.5
Parmeliopsis ambigua	--	.5	--	.5	.5	--	--	--	--	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: *Picea glauca* (10-20%) dominates the open tree layer (Table 57, Plate 47). The *Picea* ranges from *Picea glauca* at lower altitudes, through *Picea glauca* X *Picea engelmannii* hybrids at intermediate altitudes, to *Picea engelmannii* at higher altitudes. The shrub layer has moderate cover (15-35%) and is dominated by *Juniperus communis* (5-20%), *Shepherdia canadensis* (3-15%), and *Rosa acicularis* (1-5%). The herb-dwarf shrub layer has a total cover of 20 to 50%. *Arctostaphylos uva-ursi* (10-25%), *Elymus innovatus* (5-15%) and *Linnaea borealis* (3-5%) are dominant. Other characteristic species with low cover are: *Juniperus horizontalis*, *Zygadenus elegans*, *Fragaria virginiana*, *Hedysarum sulphurescens* (Banff), and *Hedysarum alpinum* (Jasper). The bryoid layer (5-10%) is sparse. Common species include *Thuidium abietinum*, *Ditrichum flexicaule*, *Tortula ruralis*, *Peltigera rufescens*, and *Peltigera canina*. Epiphytes are scarce with *Letharia vulpina*, *Parmeliopsis ambigua*, and *Cetraria pinastri* usual.

Successionally, O17 is intermediate to mature with stands 60 to 300 years old.

The O17 v.t. is closely related to O3 and intermediate stands occur. The O17 v.t. is differentiated from O3 by the absence or low cover (<1%) of *Potentilla fruticosa*, an altitude generally >1500 m (Lower Subalpine), a landform usually colluvial or morainal, and a Brunisolic soil or, if the landform is colluvial, the soil may be Regosolic. If the landform is fluvial, the soil is usually Brunisolic rather than Regosolic as in O3. In contrast, O3 generally has *Potentilla fruticosa* with >1% cover, the altitude is <1500 m (Montane), the landform is fluvial, and the soil is Regosolic.

Other Studies: Similar types have been described from as far north as southern Yukon (Douglas 1974, *Picea glauca-Shepherdia canadensis*) and southwestern Northwest Territories (Raup 1947, *Picea glauca/Juniperus communis/Arctostaphylos uva-ursi*). In Alberta, similar types have been described from the Kananaskis area (Kirby and Ogilvie 1969, *Picea/Arctostaphylos*; Jacques and Legge 1974, *Picea/Shepherdia canadensis-Arctostaphylos uva-ursi*; and Kondla 1978, spruce/juniper-lichen and spruce/buffaloberry-lichen). Ogilvie (1963) described a similar type in the Alberta Rockies (*Picea/Arctostaphylos*). In British Columbia, Kuchar (1978) described a similar type (spruce/juniper-bearberry) in Yoho National Park.

O18: ***Picea engelmannii-Abies lasiocarpa/Salix glauca/Elymus innovatus***

(Engelmann spruce-subalpine fir/willow/hairy wild rye)

Environment: The O18 v.t. occurs on mesic Lower to Upper Subalpine sites (1710-2250 m) on moderate to steep slopes of mostly southerly or westerly aspect in eastern Banff and Jasper. The soils are well drained Orthic Eutric Brunisols and Regosols predominantly on fluvial and colluvial landforms, and to a lesser extent on morainal landforms.

Vegetation: The O18 v.t. is an open forest (Plate 48) with a total tree cover of 10 to 20% (Table 58). *Picea engelmannii* (5-20%) is dominant. *Abies lasiocarpa* (≤5%) is often present. Total shrub cover is 10 to 40% with *Salix glauca* (5-30%) dominant. *Shepherdia canadensis* (≤2%) is usually present. The herb-dwarf shrub layer is well developed with 20 to 80% cover. *Elymus innovatus* (10-55%) is dominant and *Arctostaphylos uva-ursi* (2-15%) is usually present. In Banff, *Hedysarum sulphurescens* (5-25%) is frequently present and in Jasper *Hedysarum alpinum* (2-10%) is usual. Other species with high frequency but low cover are *Achillea millefolium*, *Epilobium angustifolium*, *Senecio lugens* (Banff), and *Fragaria virginiana*. Bryoid cover is variable but usually sparse. *Drepanocladus uncinatus*, *Peltigera aphthosa* and *Cladonia pyxidata* are often present with <1% cover. Epiphytes are scarce.

Table 58 Stands representing the Engelmann spruce-subalpine fir / willow / hairy wild rye (018) v.t.

	IC	JD	JD	JR	JR	JN	KS	SJ	SJ	SJ
	80	60	71	80	91	70	61	90	90	90
	91	71	69	15	65	50	12	12	14	28
TREE LAYER										
Picea engelmannii	17	15	07	15	07	11	25	05	09	08
TALL SHRUB LAYER										
Picea engelmannii	01	01	01	.5	05	03	.5	02	01	03
SHRUB LAYER										
Abies lasiocarpa	03	--	--	--	01	--	--	04	--	--
Juniperus communis	.5	.5	--	.5	03	01	--	01	--	--
Picea engelmannii	01	.5	--	.5	01	07	--	08	05	04
Salix glauca	.5	20	.5	--	05	02	30	15	30	03
Shepherdia canadensis	.5	01	--	05	--	07	--	--	--	02
HERB-DWARF SHRUB LAYER										
Achillea millefolium	.5	.5	.5	--	--	--	01	04	--	.5
Arctostaphylos uva-ursi	--	--	--	--	--	20	--	--	--	--
Arnica cordifolia	--	.5	--	08	--	--	--	--	03	03
Delphinium glaucum	--	--	--	--	--	--	--	03	05	03
Elymus innovatus	12	20	30	05	03	--	--	--	40	15
Epilobium angustifolium	07	.5	--	.5	01	--	.5	03	--	02
Fragaria virginiana	03	--	--	--	--	--	03	03	01	06
Pyrola asarifolia	--	--	--	--	.5	.5	--	--	03	--
Sedum stenopetalum	.5	--	.5	--	.5	--	--	--	--	--
Senecio lugens	--	.5	--	--	--	--	--	--	--	--
Solidago decumbens	01	--	.5	--	--	.5	--	--	--	--
Trisetum spicatum	01	--	05	--	01	--	--	--	--	--
BRYOID LAYER										
Cetraria ericetorum	--	.5	--	.5	--	.5	--	--	--	--
Cladonia pyxidata	--	--	--	.5	02	--	--	01	--	--
Dicranum scoparium	--	.5	--	--	05	05	--	--	--	--
Drepanocladus uncinatus	--	.5	--	--	--	--	20	--	--	.5
Hylocomium splendens	--	25	--	20	--	12	--	--	--	60
Peltigera aphthosa	--	.5	--	--	01	--	--	--	.5	--
Peltigera canina	--	.5	--	.5	--	--	--	--	.5	01
Peltigera rufescens	.5	--	--	--	.5	.5	--	01	--	--
Tortula ruralis	--	--	--	.5	--	--	--	10	.5	--
EPIPHYTES										
Alectoria spp.	--	.5	--	--	--	.5	--	--	--	.5
Cetraria pinastri	--	--	--	.5	.5	--	--	--	--	.5
Hypogymnia austerodes	--	--	--	.5	.5	--	--	--	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Ages of O18 stands range from 60 to >300 years. *Picea engelmannii* regeneration of all age classes is common in many stands. Even though some of the 60 to 80 year old stands might be considered intermediate, they are indistinguishable in composition and structure from the older stands. Thus, O18 is considered to be mature successionally. O18 appears to develop, following fire, by *Picea engelmannii* invasion of a shrub type like S12, which is often adjacent to O18 stands.

The O18 v.t. is distinguished from C33 by having an open forest structure and well-developed shrub layer in which *Salix glauca* is dominant.

Other Studies: No similar type has been described by other workers.

O19: *Picea engelmannii-Abies lasiocarpa/Dryas octopetala*

(Engelmann spruce-subalpine fir/mountain avens)

Environment: The O19 v.t. occurs on mesic Upper Subalpine sites (2030-2350 m) primarily in eastern Banff and northern Jasper mostly on steep slopes of various aspects. The soils are well drained Orthic Eutric and Melanic Brunisols on colluvial and morainal landforms. Solifluction is common.

Table 59 Stands representing the Engelmann spruce-subalpine fir / mountain avens (019) v.t.

	AW	JD	JD	JD	JE	LC	LC	LC	PA	PA
	61	71	80	80	90	90	90	91	90	90
	03	16	28	29	59	18	40	13	02	29
TREE LAYER										
Abies lasiocarpa	--	01	--	02	--	--	--	05	--	10
Picea engelmannii	02	13	10	05	15	05	05	--	10	10
TALL SHRUB LAYER										
Abies lasiocarpa	.5	--	--	05	--	--	--	05	--	--
Picea engelmannii	01	.5	01	--	--	05	--	--	.5	--
SHRUB LAYER										
Abies lasiocarpa	01	--	--	02	--	02	--	12	--	--
Picea engelmannii	01	.5	02	.5	--	03	05	--	.5	--
Potentilla fruticosa	06	20	--	01	--	--	--	--	--	--
Salix vestita	--	--	.5	--	20	--	--	03	--	--
HERB-DWARF SHRUB LAYER										
Androsace chamaejasme	--	.5	.5	01	--	--	--	--	--	--
Anemone parviflora	--	.5	--	.5	.5	--	--	--	--	--
Antennaria lanata	01	--	--	--	--	--	08	--	.5	--
Arctostaphylos rubra	--	--	01	03	--	--	--	02	--	.5
Arctostaphylos uva-ursi	02	05	--	15	--	10	--	--	--	--
Artemisia norvegica	--	--	--	--	--	--	--	01	.5	--
Carex scirpoidea	--	05	--	15	.5	--	--	02	--	--
Carex rupestris	--	08	02	01	--	--	--	--	--	--
Dryas octopetala	43	55	70	20	66	25	30	15	45	45
Poa alpina	--	.5	--	.5	.5	.5	03	01	.5	02
Polygonum viviparum	--	--	.5	.5	--	.5	.5	02	.5	05
Potentilla diversifolia	--	--	--	.5	--	02	--	--	.5	--
Salix arctica	--	--	01	--	01	05	15	05	.5	10
Sedum stenopetalum	--	.5	--	.5	--	.5	--	--	.5	--
Silene acaulis	--	--	.5	.5	.5	--	--	.5	--	--
Zygadenus elegans	02	02	--	01	--	--	--	.5	--	--
BRYOID LAYER										
Cetraria cucullata	--	--	.5	.5	--	--	--	--	10	10
Cetraria ericetorum	--	--	01	.5	--	.5	--	.5	.5	10
Cetraria nivalis	--	--	.5	--	--	03	05	--	.5	.5
Cladonia spp.	--	--	03	01	--	--	--	05	.5	.5
Rhytidium rugosum	--	--	.5	--	--	--	--	--	01	05
Thuidium abietinum	--	--	01	.5	--	--	--	--	02	10
Tortella fragilis	--	--	.5	.5	--	--	--	--	--	--
Tortula ruralis	--	--	02	.5	--	01	--	--	10	05

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: The open tree layer has 10 to 20% cover and is often stunted (≤5 m), (Table 59). *Picea engelmannii* (5-20%) and *Abies lasiocarpa* (5-15%) are dominant (Plate 49). The shrub layer is sparse to absent with *Picea engelmannii* and *Abies lasiocarpa* most common. Total herb-dwarf shrub cover is 30 to 80% with *Dryas octopetala* (15-45%) dominant. Other important species are *Salix arctica* (1-5%), *Carex* spp. (1-5%), *Arctostaphylos rubra* (1-3%), *Arctostaphylos uva-ursi* (<5%), *Artemisia norvegica* (Jasper) (1-2%), and *Zygadenus elegans* (1-2%). *Polygonum viviparum*, *Poa alpina*, *Sedum stenopetalum*, and *Potentilla diversifolia* occur frequently but with low cover. Bryoid cover is variable (5-45%). Common species include *Tortula ruralis*, *Tortula norvegica*, *Thuidium abietinum*, *Cetraria ericetorum*, *Cetraria islandica*, *Cetraria nivalis*, and *Cetraria cucullata*. Bare soil often covers 15 to 25% of the site.

The O19 v.t. is mature successionally and usually occurs near the upper elevational boundary of the Upper Subalpine in sites similar to those of O10 but more exposed and with less stable soils. The O19 v.t. differs from O10 in having *Dryas octopetala* dominant rather than *Phyllodoce glanduliflora* or *Cassiope mertensiana* in the herb-dwarf shrub layer.

Other Studies: Baig (1972) described a similar timberline type from the Alberta Rocky Mountains (*Abies-Picea/Dryas octopetala*).

S1: *Betula* spp.-*Potentilla fruticosa-Salix glauca/Tomenthypnum nitens*

(dwarf birch-shrubby cinquefoil-willow/brown moss)

Environment: The S1 v.t. occurs on subhygric to hydric Montane to Upper Subalpine (1350-2230 m B; 1360-2030 m J), level to gently sloping sites of various aspects. Soils are poorly to very poorly drained Gleysols and Terric Mesisols developed on fluvial and morainal landforms.

Vegetation: Tree cover is absent or sporadic (Plate 50) and this v.t. is dominated by shrubs (35-70%) (Table 60). *Betula glandulosa* or *Betula pumila* (5-20%) dominate with codominant *Potentilla fruticosa* (5-25%) and *Salix glauca* (10-40%). The herb-dwarf shrub layer has high cover (60-80%) but composition is variable with the dominant species being *Carex aquatilis* (10-40%), *Deschampsia caespitosa* (10-25%), *Rubus acaulis* (<5%), and *Pedicularis groenlandica* (<3%). The bryoid layer also has high cover (40-90%), the dominants being *Tomenthypnum nitens* (15-60%), *Aulacomnium palustre* (<20%), *Drepanocladus revolvens* (10-40%), and *Campylium stellatum* (<20%). Lichens are generally absent.

Table 60 Stands representing the dwarf birch-shrubby cinquefoil-willow / brown moss (S1) v.t.

	AW 50 17	IC 96 10	JD 50 17	RB 59 69	RB 83 08	LC 91 77	PA 80 87	PA 90 11	SJ 80 82	SJ 90 66
TALL SHRUB LAYER										
Picea engelmannii	04	--	--	--	--	--	--	--	02	--
SHRUB LAYER										
Betula glandulosa	30	30	33	--	--	20	05	05	20	07
Betula pumila	--	--	--	15	06	--	--	--	--	--
Ledum groenlandicum	15	--	--	--	--	--	--	--	--	--
Picea engelmannii	04	--	--	--	--	02	--	--	02	--
Potentilla fruticosa	25	01	25	20	03	05	.5	05	20	01
Salix barrattiana	--	--	10	--	--	10	--	--	03	15
Salix brachycarpa	--	--	--	--	08	05	--	--	--	--
Salix farrae	--	--	--	--	06	--	15	--	30	
Salix glauca	08	07	07	10	--	20	10	45	20	30
Salix myrtillifolia	--	02	--	--	--	--	--	--	07	--
Salix nivalis	--	--	--	--	--	--	--	--	13	--
HERB-DWARF SHRUB LAYER										
Achillea millefolium	--	--	--	--	--	--	--	--	05	.5
Agropyron spp.	--	--	--	--	--	--	--	10	--	--
Anemone parviflora	--	--	--	--	--	--	05	--	.5	.5
Arctostaphylos rubra	35	--	--	--	--	--	--	--	--	--
Arnica mollis	--	--	--	--	--	--	--	--	--	02
Carex aquatilis	35	23	60	03	60	05	20	05	--	01
Carex atrosquama	--	--	--	--	--	20	--	--	05	--
Carex capillaris	--	--	--	--	--	--	--	--	--	01
Carex leptalea	--	--	--	12	03	--	--	--	--	--
Carex phaeocephala	--	--	--	--	--	--	05	--	--	--
Carex rostrata	--	--	--	10	--	--	--	--	--	--
Carex vaginata	06	--	--	05	--	--	--	02	--	--
Carex spp.	--	--	--	--	--	--	--	--	05	--
Delphinium glaucum	--	--	--	--	--	--	--	--	03	03
Deschampsia caespitosa	--	--	--	20	--	06	25	10	01	--
Elymus innovatus	--	--	--	--	--	--	--	--	01	--
Eriophorum angustifolium	--	--	--	--	--	--	--	--	01	--
Fragaria virginiana	--	--	--	--	--	03	--	--	03	01
Geum macrophyllum	--	01	--	--	--	--	--	--	--	--
Hedysarum alpinum	--	--	--	--	--	--	--	--	03	--
Hierochloe odorata	--	--	--	--	--	--	--	--	06	--
Juncus balticus	--	05	--	--	--	--	--	--	--	--
Kobresia simpliciuscula	--	--	--	--	--	--	10	--	--	--
Mitella nuda	.5	--	--	--	--	--	--	--	--	04
Oxycoccus microcarpus	03	--	--	--	--	--	--	--	--	--
Pedicularis groenlandica	.5	--	01	--	--	--	03	--	--	--
Poa spp.	--	--	--	--	--	--	--	--	05	--
Polygonum viviparum	.5	--	--	--	--	.5	05	--	02	.5
Potentilla palustris	--	--	--	--	04	--	--	--	--	--
Rubus acaulis	01	01	03	06	05	03	--	.5	01	.5
Senecio indecorus	.5	--	.5	.5	--	--	--	--	--	--
Senecio lugens	--	--	15	--	--	--	--	--	--	--
Trollius albiflorus	--	--	--	--	--	--	--	--	--	05
Valeriana septentrionalis	--	--	.5	10	--	--	--	--	01	.5
Equisetum laevigatum	--	--	--	--	--	01	--	--	--	--
Equisetum variegatum	--	--	--	--	--	--	--	--	01	--
BRYOID LAYER										
Aulacomnium palustre	--	04	.5	10	05	50	--	20	05	01
Barbilophozia lycopodioides	--	--	--	--	--	05	--	--	--	--
Brachythecium turgidum	--	.5	--	--	--	--	--	05	--	--
Bryum pseudotriquetrum	--	.5	--	--	10	--	.5	.5	--	.5
Bryum spp.	--	--	--	.5	.5	--	--	--	.5	--
Campylium stellatum	.5	--	.5	10	30	--	15	05	--	--
Ceratodon purpureus	--	--	--	--	--	02	--	--	--	--
Cladonia pyxidata	--	--	--	--	--	.5	--	--	.5	--
Drepanocladus revolvens	--	--	03	30	40	10	--	--	--	--
Drepanocladus sendtneri	--	--	--	--	--	--	--	10	--	--
Drepanocladus uncinatus	--	01	--	--	--	--	--	--	--	03
Peltigera aphthosa	--	--	--	--	--	--	--	--	04	.5
Sphagnum warnstorfii	30	--	03	05	--	--	--	--	--	--
Tomenthypnum nitens	20	15	75	15	--	10	--	.5	01	02
Tortula ruralis	--	--	--	--	--	--	--	--	.5	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Successionally S1 is mature.

The S1 v.t. is distinguished from S3 by the absence or very low abundance of *Scirpus caespitosus* which is the dominant herb in S3. The S1 has a generally wetter environment, lower elevation and low *Salix barrattiana* and *Erigeron peregrinus* cover compared with S4. The S1 v.t. differs from S9 and S10 by being much wetter, having much less *Kobresia myosuroides* than S9 and much more gentle slopes than S10.

Other Studies: In Alberta, similar types have been described by Jeffrey et al. (1968, *Salix-Potentilla-Betula*) and by Kondla (1978) in Kananaskis Provincial Park (birch-willow wetland). In British Columbia, Kuchar (1978) described a dwarf birch shrub meadow in Yoho National Park.

Table 61 Stands representing the subalpine fir-willow (S2) v.t.

	JC 83 90 90	JD 80 91 90	JD 80 91 90	JB 80 91 16	JB 80 91 33	RB 83 91 40	LC 91 91 03	LC 91 91 68	SJ 90 90 87	SJ 90 90 90
TALL SHRUB LAYER										
Abies lasiocarpa	11	05	01	--	10	--	.5	--	--	--
Picea engelmannii	03	--	01	--	--	--	--	--	--	--
Pinus albicaulis	10	--	--	--	--	--	--	--	--	--
SHRUB LAYER										
Abies lasiocarpa	--	10	45	35	60	25	20	08	10	45
Rhododendron albiflorum	--	--	--	25	--	--	--	--	--	--
Salix barclayi	--	--	--	--	--	--	--	04	05	--
Salix barrattiana	--	05	--	--	--	--	--	--	--	06
Salix farrae	--	--	--	--	--	30	--	--	--	02
Salix glauca	--	30	--	--	10	10	--	--	--	03
Salix vestita	--	--	20	01	--	--	--	--	05	02
Salix spp.	--	--	05	--	--	--	--	--	--	--
HERB-DWARF SHRUB LAYER										
Abies lasiocarpa	--	--	--	--	07	--	--	05	--	--
Achillea millefolium	--	01	--	--	--	.5	--	--	--	--
Aconitum delphinifolium	--	--	--	--	--	--	--	--	01	02
Anemone occidentalis	--	--	--	10	06	02	05	10	--	--
Antennaria lanata	--	--	--	--	--	01	--	--	--	--
Aquilegia formosa	--	--	--	--	--	--	--	--	12	--
Aquilegia flavescens	--	03	02	01	--	--	--	--	--	.5
Arabis drummondii	--	--	--	--	--	--	--	.5	01	--
Arctostaphylos uva-ursi	--	05	--	--	--	--	--	--	--	--
Arnica alpina	--	--	--	--	--	--	--	02	--	--
Arnica latifolia	--	--	--	02	--	--	--	--	--	--
Artemisia norvegica	--	--	02	03	02	--	08	02	03	05
Aster ciliolatus	--	02	--	--	--	04	--	--	--	--
Astragalus frigidus	--	03	--	--	--	--	--	--	--	--
Bromus pumpellianus	--	15	--	--	--	--	--	--	--	--
Carex limosa	--	--	--	--	--	--	--	05	--	--
Carex pyrenaica	--	--	--	--	10	--	--	--	--	--
Carex scirpoidea	--	01	--	--	--	.5	05	--	--	--
Carex spectabilis	--	--	--	--	--	--	12	--	--	--
Carex tolmiei	--	--	02	20	--	--	--	--	--	--
Cassiope mertensiana	01	--	--	--	--	--	10	--	--	--
Elymus innovatus	--	.5	06	--	--	--	--	--	06	02
Empetrum nigrum	01	--	--	02	--	--	--	--	--	--
Epilobium angustifolium	--	.5	--	03	03	03	01	05	08	06
Erigeron peregrinus	--	01	03	01	02	10	--	--	03	03
Fragaria virginiana	--	15	--	--	--	06	--	--	05	02
Hackelia jessicae	--	--	--	.5	--	--	--	--	02	--
Hedysarum sulphurescens	--	03	--	--	--	--	--	--	--	--
Heracleum lanatum	--	.5	.5	.5	.5	--	--	--	02	02
Luzula wahlenbergii	--	--	--	--	.5	--	--	--	--	--
Pedicularis bracteosa	.5	02	03	03	.5	02	01	--	04	01
Phleum alpinum	--	--	--	--	.5	.5	--	01	--	--
Phyllodoce empetriformis	--	--	--	--	--	--	08	--	--	--
Phyllodoce spp.	01	--	--	--	--	--	--	04	--	--
Poa arctica	--	--	--	--	--	--	--	02	--	--
Pyrola asarifolia	--	.5	--	.5	--	.5	--	--	--	01
Ranunculus eschscholtzii	--	--	--	01	--	--	.5	--	03	--
Rubus pedatus	--	--	--	--	02	--	--	--	--	--
Senecio triangularis	--	--	.5	03	05	05	01	03	02	05
Thalictrum occidentale	--	02	08	10	03	--	--	03	12	10
Trisetum spicatum	--	01	--	--	--	.5	--	.5	--	--
Trollius albiflorus	--	--	02	--	--	08	--	--	--	03
Vaccinium caespitosum	--	--	--	--	--	--	--	02	--	.5
Vaccinium membranaceum	--	--	--	02	--	--	02	04	--	--
Vaccinium scoparium	--	--	--	--	--	10	--	--	--	--
Valeriana sitchensis	--	02	10	15	08	12	12	06	12	05
Veratrum eschscholtzii	--	--	01	05	.5	01	.5	05	01	02
Veronica alpina	--	--	.5	--	.5	--	--	01	--	.5
Viola orbiculata	--	--	--	--	--	--	02	--	--	01
Sedum divergens	--	--	--	--	--	--	--	02	--	--
Equisetum arvense	--	--	--	--	--	06	--	--	--	.5
BRYOID LAYER										
Brachythecium groenlandicum	--	--	--	--	--	--	10	--	--	--
Brachythecium spp.	--	--	--	--	--	30	--	--	--	--
Ceratodon purpureus	--	--	--	--	--	--	--	03	--	--
Cladonia ochrochlora	--	.5	--	--	.5	--	--	--	--	--
Cladonia pyxidata	--	.5	.5	.5	--	--	--	06	--	.5
Dicranoweisia crispula	--	--	--	.5	.5	.5	--	--	--	--
Dicranum scoparium	--	--	.5	--	05	--	10	--	--	--
Dicranum spp.	45	--	--	--	--	--	--	--	--	--
Peltigera aphthosa	02	--	--	--	--	--	--	--	--	--
Peltigera canina	--	--	--	--	--	--	--	--	--	--
Peltigera spp.	--	--	--	--	--	--	--	.5	--	.5
Pleurozium schreberi	--	--	--	--	--	--	--	03	--	--
Polytrichum juniperinum	05	--	--	--	--	--	--	--	--	--
Pseudoleskea radicosa	02	--	--	--	--	--	05	02	--	--
Rhizocarpon geographicum	--	.5	.5	10	.5	--	10	10	--	--
Barbilophozia hatcheri	--	--	.5	.5	.5	--	--	--	--	--
Barbilophozia lycopodioides	38	--	--	--	--	--	--	02	--	--
	--	--	03	.5	.5	--	05	02	--	01
EPIPHYTES										
Cetraria pinastri	--	--	--	--	.5	--	--	--	--	--
Parmeliopsis hyperopta	--	--	--	--	.5	--	--	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

S2: *Abies lasiocarpa-Salix* spp./*Valeriana sitchensis*

(subalpine fir-willow)

Environment: The S2 v.t. occurs on mesic to subhygric, Lower to Upper Subalpine (1600 - 2100 m J, - 2240 m B) steeply sloping snow avalanche paths on various aspects. Soils are predominantly Regosols and Eutric and Dystric Brunisols developed on colluvial landforms.

Vegetation: Dwarfed *Abies lasiocarpa* (10-70%) is the dominant shrub (Table 61). *Salix vestita* (10-20%) and *Salix glauca* (5-30%) occur in most plots but with generally lower cover than *Abies*, with combined *Salix* spp. cover 20 to 60% (Plate 51). *Rhododendron albiflorum* and *Menziesia glabella* may be abundant in some stands, particularly in western portions of Banff and Jasper. The herb-dwarf shrub layer is usually well developed (20-70%) and is dominated by *Valeriana sitchensis* (<15%), *Epilobium angustifolium* (<10%), *Artemisia norvegica*, (Jasper, <20%), *Thalictrum occidentale* (<15%), and *Pedicularis bracteosa* (<12%). The bryoid layer is generally poorly developed although *Pleurozium schreberi*, *Barbilophozia* spp., or *Brachythecium* spp. may locally account for >30% cover. Epiphytic lichens are sparse.

The moist conditions of S2 separate it from the generally dry S10, also strongly influenced by avalanching. Some stands are transitional to H5 on sites with low shrub cover.

The varying avalanche frequency in conjunction with other environmental factors results in variable though more or less stable vegetation of stunted physiognomy. Thus, S2 is best considered mature successionally, although it has characteristics of earlier successional stages.

Other Studies: Similar vegetation was described by Butler (1979) in Glacier National Park, Montana, by Trottier and Scotter (1973) on avalanche paths in Banff (*Picea-Abies/Alnus crispa-Vaccinium scoparium/Heracleum lanatum*), and by Kuchar (1978) in Yoho National Park (deciduous avalanche scrub).

S3: *Betula glandulosa-Potentilla fruticosa/Scirpus caespitosus/Drepanocladus revolvens* (dwarf birch-shrubby cinquefoil/needlerush)

Environment: The S3 v.t. occurs on subhydric to hydric, Lower Subalpine sites (1450-1900 m) on nearly level slopes of various aspects. The soils are poorly to very poorly drained Terric Mesisols and Orthic Gleysols on glacial, glaciolacustrine, and fluvial landforms.

Vegetation: The shrub layer (Plate 52) has a total cover of 5 to 25% with *Betula glandulosa* (2-15%) and *Potentilla fruticosa* (<1-15%) dominant (Table 62). *Salix barrattiana* and *Ledum groenlandicum* often occur with low cover. The herb-dwarf shrub layer is dominated by herbs and has a total cover of 60 to 95%. *Scirpus caespitosus* (20-80%) is dominant with *Carex aquatilis* (5-15%) and *Pedicularis groenlandica* (1-5%) being the other main species. Common species with low cover values include *Anemone parviflora*, *Eriophorum angustifolium*, *Antennaria lanata*, *Carex capillaris*, *Deschampsia caespitosa*, *Polygonum viviparum*, *Equisetum arvense*, and *Equisetum variegatum*. Total bryoid layer cover is 60 to 90% with mosses predominant. Important species are *Drepanocladus revolvens* (20-80%), *Tomenthypnum nitens* (5-40%), and *Campylium stellatum* (1-30%). *Aulacomnium palustre* and *Sphagnum warnstorfii* occur frequently but usually with low cover.

Table 62 Stands representing the dwarf birch-shrubby cinquefoil / needlerush (S3) v.t.

	AW	IC	IC	JD	JE	KS	KS	LC	PA	PA
	60	60	90	50	91	50	90	91	70	71
	50	36	49	75	04	32	89	62	16	08
SHRUB LAYER										
Betula glandulosa	09	02	05	10	09	12	10	13	15	02
Ledum groenlandicum	07	01	--	--	--	--	--	--	02	.5
Potentilla fruticosa	12	01	01	--	06	08	15	16	05	05
Salix barrattiana	01	--	--	--	.5	06	02	--	--	--
HERB-DWARF SHRUB LAYER										
Anemone parviflora	09	01	01	.5	.5	--	04	--	--	02
Antennaria lanata	--	--	--	.5	.5	--	10	.5	--	.5
Carex aquatilis	--	.5	08	--	--	60	06	--	10	--
Carex spp.	03	04	--	15	--	25	--	10	--	21
Deschampsia caespitosa	--	--	--	.5	--	--	--	01	--	--
Equisetum arvense	.5	--	--	--	--	.5	06	--	--	--
Equisetum variegatum	.5	.5	--	--	--	01	.5	--	--	--
Pedicularis groenlandica	--	01	--	05	--	.5	02	.5	01	.5
Scirpus caespitosus	18	75	60	60	25	05	40	50	50	60
Vaccinium vitis-idaea	01	--	--	--	--	--	--	--	--	--
BRYOID LAYER										
Aulacomnium palustre	12	--	--	35	02	--	--	--	.5	15
Campylium stellatum	--	20	38	.5	.5	05	02	.5	40	25
Drepanocladus revolvens	--	--	55	.5	87	80	95	--	40	.5
Sphagnum spp.	20	--	--	.5	01	--	--	05	--	.5
Tomenthypnum nitens	65	--	--	--	--	--	02	55	01	20

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

S3 is mature successionally, and is distinguished from other wet shrub v.t.s, including S1, by the dominance of *Scirpus caespitosus* in the herb-dwarf shrub layer.

Other Studies: Kuchar (1978) described a deer hair bulrush meadow in Yoho National Park, British Columbia.

S4: *Salix* spp.-*Betula glandulosa/Erigeron peregrinus*

(willow-dwarf birch/fleabane)

Environment: The S4 v.t. occurs on hygric to mesic, predominantly Upper Subalpine sites (1850-2300 m) on nearly level to moderate slopes on all aspects. The soils are Gleysols,

Regosols, and Eutric Brunisols. Drainage is mostly moderately well to poor, although both well and very poorly drained sites also occur. The wide range of moisture regime and drainage class suggests a fluctuating water table in these sites. The landforms are fluvial and morainal.

Vegetation: *Salix glauca* (10-45%) is typically the dominant shrub (Table 63). *Betula glandulosa* (10-50%) is often dominant to codominant with *Salix glauca*, but may be absent. *Salix barrattiana* (5-20%) is often present but never dominant. Total shrub cover is 45 to 85% (Plate 53). Total herb-dwarf shrub layer cover is 35 to 70% with herbs much more important than dwarf shrubs. Common dominants include *Erigeron peregrinus* (3-10%), *Fragaria virginiana* (1-10%), *Potentilla diversifolia* (1-3%), and *Artemisia norvegica* (Jasper), (1-5%). Other common species with low cover are *Achillea millefolium*, *Phleum alpinum*, *Trollius albiflorus*, and *Valeriana sitchensis*. Bryoid layer cover is generally 15 to 35% with *Aulacomnium palustre*, *Drepanocladus uncinatus*, *Tomenthypnum nitens*, *Dicranum scoparium*, and *Peltigera rufescens* most common.

Table 63 Stands representing the willow-dwarf birch / fleabane (S4) v.t.

	IC 80 23	JC 80 56	JD 50 44	JD 80 31	JD 80 70	KS 51 32	PA 80 70	PA 80 78	PA 80 90	PA 90 80
SHRUB LAYER										
Betula glandulosa	40	10	--	01	60	05	50	75	40	30
Potentilla fruticosa	--	20	--	.5	--	10	--	.5	--	05
Salix barrattiana	--	--	10	20	03	05	05	10	.5	15
Salix farrae	--	--	--	10	--	15	--	--	15	05
Salix glauca	45	25	25	50	20	60	05	05	30	20
HERB-DWARF SHRUB LAYER										
Achillea millefolium	01	03	07	.5	01	.5	.5	.5	02	.5
Agoseris glauca	--	--	.5	--	.5	--	.5	.5	--	.5
Castilleja occidentalis	--	02	--	--	01	--	.5	--	--	03
Delphinium glaucum	--	--	--	.5	02	--	--	.5	05	01
Deschampsia caespitosa	--	01	--	01	--	--	--	--	10	--
Elymus innovatus	09	--	02	--	20	--	05	05	--	--
Epilobium angustifolium	03	--	15	--	01	--	--	--	--	--
Erigeron peregrinus	05	15	02	15	30	03	02	01	15	15
Fragaria virginiana	--	08	10	15	.5	05	--	--	--	05
Lusula wahlenbergii	.5	.5	--	--	02	--	--	--	--	--
Phleum alpinum	--	02	01	--	--	.5	--	--	.5	--
Poa alpina	--	--	05	.5	01	--	--	--	.5	--
Poa sp.	.5	.5	--	01	01	--	--	--	--	--
Polygonum viviparum	01	02	--	.5	--	--	--	--	--	--
Potentilla diversifolia	02	03	.5	.5	05	--	01	.5	--	05
Senecio indecorus	--	--	.5	--	--	.5	--	--	--	.5
Senecio lugens	--	05	--	01	--	--	01	.5	01	--
Sibbaldia procumbens	.5	01	--	--	.5	--	--	--	--	--
Solidago multiradiata	--	01	--	01	01	--	.5	--	.5	--
Thalictrum venulosum	--	01	--	--	02	--	--	--	--	--
Trisetum spicatum	--	--	.5	--	15	.5	--	--	--	-
Trollius albiflorus	--	10	05	--	--	02	.5	--	--	20
Valeriana sitchensis	--	--	01	02	20	--	--	--	03	03
BRYOID LAYER										
Aulacomnium palustre	--	15	--	--	--	--	--	--	--	15
Brachythecium groenlandicum	.5	--	--	.5	--	--	--	.5	--	.5
Cetraria ericetorum	.5	--	--	--	.5	--	--	--	--	--
Cladonia pyxidata	.5	--	--	.5	--	--	.5	--	--	.5
Ditrichum flexicaule	--	--	.5	--	--	--	--	--	--	05
Hylocomium splendens	01	--	--	--	--	--	--	--	--	03
Peltigera aphthosa	.5	--	--	--	--	--	--	--	--	.5
Peltigera rufescens	--	--	--	--	--	--	--	.5	--	--
Polytrichum juniperinum	01	--	--	--	01	--	--	--	--	--
Tomenthypnum nitens	01	--	--	--	--	--	--	--	--	02
Tortula norvegica	--	--	.5	.5	--	10	--	.5	--	--
Tortula ruralis	.5	--	--	--	05	--	10	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The S4 v.t. is mature successionally.

The S4 v.t. is differentiated from the very similar S12 by having <10% cover of *Elymus innovatus* and greater cover of *Betula glandulosa* and *Salix barrattiana*. The S10 v.t. is drier than S4, being typically mesic to subxeric, well to rapidly drained, without gleyed soils or *Salix barrattiana* but often with *Arctostaphylos uva-ursi*. *Betula glandulosa* may be dominant to codominant in S10. The S8 v.t. is differentiated by *Salix barrattiana* being dominant. Intergrades between S4 and S8, S10 or S12 occur.

Other Studies: Similar vegetation has been described in the Kananaskis area of Alberta by Kirby and Ogilvie (1969) and by Kondla (1978, birch wetland).

S6: *Salix scouleriana-Alnus crispa/Mertensia paniculata*

(willow-green alder/bluebell)

Environment: The S6 v.t. occurs on subhygric to hygric, Lower Subalpine sites (1300-1600 m) on moderate slopes of northerly aspect in Jasper. The soils are moderately well drained Orthic Eutric Brunisols with seepage, on morainal landforms.

Table 64 Stands representing the willow-green alder / bluebell (S6) v.t.

	IC 50 19	IC 51 08	IC 51 35	IC 70 20	IC 70 53	JM 71 00
TALL SHRUB LAYER						
Abies lasiocarpa	--	--	--	--	01	--
Alnus crispa	65	10	05	80	--	--
Alnus tenuifolia	--	25	--	--	10	15
Picea glauca	--	--	--	--	01	01
Salix scouleriana	35	--	60	10	10	07
SHRUB LAYER						
Ledum groenlandicum	.5	--	01	--	.5	--
Lonicera involucrata	03	.5	.5	--	05	--
Ribes lacustre	--	--	--	01	02	01
Rosa acicularis	05	10	15	--	02	15
Rubus strigosus	02	--	40	01	01	--
Viburnum edule	05	02	.5	--	02	07
HERB-DWARF SHRUB LAYER						
Arnica cordifolia	40	--	--	02	--	01
Calamagrostis canadensis	.5	02	05	--	05	--
Cornus canadensis	.5	.5	05	--	15	05
Elymus innovatus	--	01	05	01	--	30
Epilobium angustifolium	01	.5	03	--	02	.5
Galium triflorum	.5	--	01	--	02	.5
Linnaea borealis	02	01	02	--	03	03
Mertensia paniculata	05	--	01	--	03	05
Mitella nuda	--	.5	.5	--	02	01
Petasites palmatus	--	01	01	--	02	--
Rubus pubescens	.5	10	--	--	02	10
Viola renifolia	.5	.5	--	--	02	01
BRYOID LAYER						
Cladonia spp.	.5	--	--	--	.5	.5
Drepanocladus uncinatus	.5	--	--	--	10	03
Hylocomium splendens	--	--	--	--	01	02
Pleurozium schreberi	--	05	--	--	08	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: The S6 v.t. is dominated by tall shrubs (Plate 54) usually 3 to 10 m high (Table 64). This upper shrub layer is dense (35-90%) and dominated by *Salix scouleriana* (10-60%) and *Alnus crispa* (10-80%). Some stands have *Alnus tenuifolia* (10-30%). The lower shrub layer (0.5-2 m high) has a total cover of 20 to 25% and is dominated by *Rosa acicularis* (5-15%) with lesser amounts of *Rubus strigosus* (7%), *Viburnum edule* (3%), and *Lonicera involucrata* (1%). Herb-dwarf shrub cover is 25 to 50% commonly with *Mertensia paniculata* (2%), *Cornus canadensis* (5%), *Rubus pubescens* (4%), and *Calamagrostis canadensis* (3%). Other species with high frequency but low cover include *Epilobium angustifolium, Galium triflorum, Viola renifolia,* and *Moneses uniflora.* Bryophytes and lichens, both terrestrial and epiphytic, are scarce.

Stands of the S6 v.t. often contain a few *Pinus contorta* trees but succession to a forest like C10 does not appear likely. Thus, S6 is regarded as a mature successional stage.

The S6 v.t., dominated by tall willow and alder, is quite distinct from other v.t.s.

Other Studies: No similar type has been described by other workers.

S7: *Salix* spp./*Equisetum arvense*

(willow/horsetail)

Environment: The S7 shrub thickets occur on hygric, Montane to Lower Subalpine (1000-1880 m), level to gently sloping fluvial landforms of various aspects. Soils are imperfectly to poorly drained Rego Gleysols and Regosols that are subject to periodic flooding and sediment deposition.

Vegetation: Tree cover is absent or limited to scattered individuals, particularly on nearly stable floodplains and fans. Shrub cover is high (25-80%, Plate 55) and is comprised largely of one or more of the following *Salix* spp. (Table 65) which may have widely ranging cover values: *Salix glauca, Salix bebbiana, Salix planifolia, Salix myrtillifolia,* and *Salix farrae. Potentilla fruticosa* (<1%) is often present. The herb-dwarf shrub layer is also dense (25-75%) and is as heterogeneous as the shrub layer, a reflection of the early successional stage and consequent random establishment of a wide variety of species, giving this v.t. a weedy appearance. The dominant herb is *Equisetum arvense* (1-25%). Some other more frequently occurring species include *Fragaria virginiana* (<6%), *Achillea millefolium* (<2%), *Vicia americana* (<6%), and *Taraxacum officinale* (<1%) , but many other species may be locally abundant, especially *Carex* spp.. The bryoid layer has generally low cover (<20%) attributable to *Drepanocladus* spp. and several other hydrophytic species.

Table 65 Stands representing the willow / horsetail (S7) v.t.

	AW 60 44	IC 50 82	IC 80 04	JN 70 02	JN 81 18	LC 90 99	SJ 81 05	SJ 90 97	SJ 91 03	SJ 91 13
TREE LAYER										
Picea engelmannii	05	--	--	--	--	--	--	--	--	--
Picea glauca	--	--	10	--	--	--	.5	--	--	--
Pinus contorta	02	--	--	--	--	--	--	--	--	--
TALL SHRUB LAYER										
Betula pumila	--	--	--	--	01	--	--	--	--	--
Picea glauca	--	--	04	--	--	--	.5	--	--	--
Salix bebbiana	--	--	01	--	--	--	14	--	--	--
Salix spp.	--	--	--	40	01	--	--	--	--	--
SHRUB LAYER										
Alnus crispa	--	--	01	--	--	--	--	--	--	--
Betula glandulosa	--	--	--	--	--	--	--	--	02	02
Betula pumila	--	--	01	--	--	--	--	--	--	--
Cornus stolonifera	--	--	--	.5	--	--	02	--	--	--
Elaeagnus commutata	--	--	02	--	--	--	--	--	--	--
Lonicera dioica	--	--	--	--	--	--	25	--	--	--
Lonicera involucrata	01	--	--	--	--	--	--	--	--	--
Picea complex	--	--	--	--	--	--	--	--	01	--
Picea engelmannii	03	--	--	--	--	--	--	--	--	--
Picea glauca	--	--	05	--	--	--	--	--	--	02
Pinus contorta	01	--	--	--	--	--	--	--	--	01
Populus tremuloides	.5	.5	--	--	--	--	--	--	--	--
Potentilla fruticosa	.5	--	.5	--	01	--	--	--	--	01
Rosa acicularis	--	01	--	.5	--	--	15	--	--	--
Rubus strigosus	--	--	--	--	--	--	10	--	--	--
Salix bebbiana	--	--	28	--	01	--	--	--	--	--
Salix brachycarpa	.5	--	--	--	--	--	--	--	10	--
Salix commutata	--	--	--	--	--	--	15	--	--	--
Salix drummondiana	--	--	--	--	--	--	15	--	--	--
Salix farrae	--	--	--	--	--	--	--	--	08	15
Salix glauca	65	--	--	--	--	--	--	--	30	--
Salix myrtillifolia	--	--	--	--	--	--	25	--	--	--
Salix planifolia	--	25	--	--	56	--	--	--	--	--
Salix pseudomonticola	--	--	--	--	01	--	--	--	--	--
Salix vestita	--	--	--	--	--	--	--	--	01	.5
Salix spp.	10	--	02	03	--	--	--	--	--	--
HERB-DWARF SHRUB LAYER										
Achillea millefolium	.5	01	--	--	--	--	--	02	--	--
Agropyron repens	--	35	--	--	--	--	--	--	--	--
Antennaria lanata	--	--	--	--	--	--	--	--	--	03
Arctostaphylos rubra	--	--	--	--	--	--	--	--	01	02
Artemisia michauxiana	--	--	--	--	--	--	--	03	--	--
Aster ciliolatus	01	--	--	--	--	--	--	01	--	--
Aster junciformis	--	--	--	--	--	03	--	--	--	--
Carex aquatilis	--	--	--	--	--	--	10	--	--	--
Carex concinna	--	--	--	02	--	--	--	--	--	.5
Carex garberi	--	--	--	--	--	--	--	--	08	--
Carex microglochin	--	--	--	--	--	--	--	--	20	--
Carex rostrata	--	--	--	--	--	03	07	--	05	--
Carex viridula	--	--	--	--	--	07	--	--	--	--
Castilleja occidentalis	--	--	--	--	--	--	--	--	02	07
Deschampsia caespitosa	--	--	--	--	--	--	03	--	--	--
Dryas drummondii	--	--	--	--	.5	--	--	--	--	07
Elymus innovatus	07	--	15	--	--	--	--	--	--	--
Epilobium angustifolium	01	--	--	--	--	--	--	01	--	--
Equisetum arvense	--	.5	--	40	.5	25	01	25	--	13
Eriophorum scheuchzeri	--	--	--	--	--	--	--	02	--	--
Fragaria virginiana	06	.5	.5	--	--	--	--	--	--	.5
Hedysarum alpinum	--	--	--	--	--	--	--	--	07	.5
Juncus alpinus	--	--	--	--	07	--	--	--	--	--
Juncus balticus	--	--	05	--	--	--	--	--	--	--
Linnaea borealis	03	--	--	--	--	--	--	--	--	--
Phleum pratense	--	.5	--	--	--	--	25	--	--	--
Poa pratensis	--	35	--	--	--	--	--	--	--	--
Poa spp.	--	--	--	--	17	--	--	--	--	01
Pyrola asarifolia	--	--	01	--	--	--	--	--	01	.5
Senecio indecorus	12	--	--	--	--	--	--	--	--	--
Taraxacum officinale	--	.5	--	01	--	--	.5	--	--	--
Urtica spp.	--	--	--	--	--	--	25	--	--	--
Vicia americana	--	.5	.5	--	--	--	06	--	--	--
Viola palustris	--	--	--	--	06	--	--	--	--	--
BRYOID LAYER										
Aulacomnium palustre	--	--	--	--	--	10	--	--	--	--
Bryum pseudotriquetrum	--	--	10	--	--	--	--	05	--	--
Bryum spp.	--	--	--	.5	01	--	--	--	.5	.5
Campylium stellatum	--	--	--	--	12	--	--	--	--	--
Ceratodon purpureus	--	.5	.5	--	.5	--	--	--	--	--
Drepanocladus revolvens	--	--	--	--	03	--	--	50	--	--
Drepanocladus uncinatus	02	--	.5	--	--	--	--	--	--	--
Fissidens adiantoides	--	--	--	--	--	02	--	--	--	--
Funaria hygrometrica	--	--	--	--	--	--	--	--	05	--
Peltigera rufescens	--	05	--	--	--	--	--	--	--	--
Tortula ruralis	--	.5	.5	--	--	--	.5	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Successionally, S7 is early to intermediate, following H3 and preceding O3 on stable sites.

The S7 v.t. is distinguished from the other shrub v.t.s by its Montane to Lower Subalpine location, abundance of *Equisetum arvense* and its occurrence on recent alluvial locations. Stands transitional to S11 occur at higher elevations.

Other Studies: Descriptions of similar types by other authors were not found.

S8: *Salix barrattiana/Potentilla diversifolia*

(willow/cinquefoil)

Environment: The S8 v.t. occurs on subhygric to hygric Upper Subalpine sites (2000-2380 m B; 1900-2250 m J) on gentle to moderate slopes on mostly northerly and easterly aspects. The soils are moderately well to poorly drained Gleysols and Regosols. Seepage is common through much of the growing season. The landforms are primarily fluvial and to a lesser extent morainal.

Table 66 Stands representing the willow / cinquefoil (S8) v.t.

	AW	IC	JC	JD	JD	JE	LC	PA	PA	SJ
	51	61	60	50	80	80	90	70	80	70
	33	33	71	51	37	33	39	24	80	57
SHRUB LAYER										
Salix barrattiana	09	50	80	50	75	50	68	35	50	35
Salix glauca	--	05	--	20	03	25	05	--	40	.5
HERB-DWARF SHRUB LAYER										
Achillea millefolium	--	.5	--	05	--	.5	--	--	--	--
Anemone parviflora	--	.5	01	--	01	--	--	.5	--	--
Aquilegia flavescens	.5	--	--	--	.5	03	--	02	--	--
Artemisia norvegica	--	.5	--	--	--	--	--	--	--	02
Castilleja occidentalis	.5	--	.5	--	--	--	--	--	--	01
Elymus innovatus	--	01	--	02	--	--	20	--	--	--
Epilobium angustifolium	--	--	--	03	--	--	02	--	.5	.5
Equisetum scirpoides	--	.5	01	02	--	04	05	--	--	.5
Erigeron peregrinus	.5	--	.5	02	15	.5	--	--	10	.5
Fragaria virginiana	.5	01	.5	60	20	--	02	--	--	--
Pedicularis bracteosa	.5	--	01	--	01	--	--	15	--	--
Pedicularis groenlandica	--	--	--	--	--	08	--	--	--	--
Phleum alpinum	.5	.5	--	--	--	--	01	--	01	--
Poa alpina	01	--	.5	--	01	--	--	--	--	--
Polygonum viviparum	.5	.5	--	--	01	.5	--	01	--	.5
Potentilla diversifolia	.5	06	.5	.5	05	02	20	.5	10	.5
Pyrola asarifolia	--	.5	02	.5	.5	--	--	--	--	--
Salix arctica	04	--	--	--	01	--	--	.5	--	.5
Senecio indocorus	.5	.5	--	05	.5	--	--	--	--	.5
Senecio triangularis	--	--	06	--	--	.5	02	--	--	.5
Sibbaldia procumbens	01	.5	01	--	--	--	--	.5	--	--
Trollius albiflorus	.5	--	05	--	10	08	--	20	10	.5
Valeriana sitchensis	.5	--	10	--	15	01	02	02	10	--
BRYOID LAYER										
Brachythecium spp.	--	--	.5	.5	.5	.5	--	.5	.5	--
Bryum pseudotriquetrum	--	--	02	--	--	.5	--	.5	05	03
Peltigera aphthosa	--	--	01	.5	--	.5	--	--	--	02
Tortula norvegica	--	--	03	--	.5	--	05	.5	05	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: The shrub layer (Plate 56) has a total cover of 40 to 75% with *Salix barrattiana* (20-60%) dominant (Table 66). *Salix glauca* (5-20%) is often present also. Total herb-dwarf shrub layer cover is 30 to 70% with herbs much more important than dwarf shrubs. This layer is species-rich with many species having low cover. Common dominants include *Potentilla diversifolia* (1-5%), *Trollius albiflorus* (3-15%), *Erigeron peregrinus* (3-10%), and *Artemisia norvegica*, Jasper (1-10%). Other common species with low cover are *Polygonum viviparum*, *Valeriana sitchensis*, *Pedicularis bracteosa*, *Senecio triangularis*, *Fragaria virginiana*, *Achillea millefolium*, *Castilleja occidentalis*, and *Sibbaldia procumbens*. Bryoid cover is quite variable but usually <30%. Common species include *Aulacomnium palustre*, *Tortula norvegica*, *Bryum pseudotriquetrum*, and *Brachythecium* spp.

The S8 v.t. is mature successionally.

The S8 v.t. is differentiated from other similar shrub v.t.s by *Salix barrattiana* dominance. Intergrades to S4 and S12 occur.

Other Studies: In Banff, similar types have been described by Trottier and Scotter (1973, *Salix barrattiana-Betula glandulosa/Carex* spp., *Salix barrattiana/Carex nigricans*), Beder (1967), Broad (1973), and Knapik et al. (1973). In Jasper, similar types have been described by Crack (1977) and Kuchar (1975). Elsewhere in Alberta, Ogilvie (1976), Mortimer (1978, *Salix barrattiana-Trollius albiflorus*), Jacques and Legge (1974, tall willow), and Trottier (1972) have described similar types.

S9: *Betula glandulosa-Salix glauca/Kobresia myosuroides*

(dwarf birch-willow/kobresia)

Environment: The S9 v.t. occurs on predominantly mesic Lower to Upper Subalpine (1740-2210 m B, 1380-2060 m J), level to gently sloping sites of various aspects in eastern Banff and Jasper. Soils are well to imperfectly drained Regosols, Brunisols, and Rego Gleysols developed on fluvial landforms. The generally coarse soil textures and consequent rapid surface drainage often result in mesic vegetation even though the water table may be at <1m.

Vegetation: *Betula glandulosa* (15-50%) is the dominant shrub (Table 67). Also important are *Salix glauca* (10-30%) and *Potentilla fruticosa* (5-20%), contributing to total shrub cover of 20 to 85% (Plate 57). Herb-dwarf shrub layer cover is generally high (55-90%) dominated by *Kobresia myosuroides* (15-50%). Other characteristic herbs are *Achillea millefolium* (<2%), *Elymus innovatus* (2-15%) and *Fragaria virginiana* (2-8%). The cover of the bryoid layer is generally low (3-15%), the most common species being *Tortula ruralis* (≤5%). *Thuidium abietinum*, *Cetraria ericetorum*, *Cladonia pyxidata*, and *Peltigera rufescens* are other frequently occurring species which usually have ≤1% cover.

Table 67 Stands representing the dwarf birch-willow / kobresia (S9) v.t.

	IC	JC	JD	JE	JE	JE	JM	PA	PA	SJ
	80	80	90	80	80	81	80	81	91	80
	71	20	78	60	99	16	55	01	17	56
SHRUB LAYER										
Betula glandulosa	55	50	40	25	15	15	30	15	20	30
Potentilla fruticosa	--	--	.5	15	05	05	.5	.5	--	02
Salix barrattiana	--	--	20	--	--	--	--	--	--	--
Salix brachycarpa	--	--	--	--	--	07	--	--	--	--
Salix glauca	20	--	35	45	15	08	17	10	20	07
HERB-DWARF SHRUB LAYER										
Achillea millefolium	.5	02	02	.5	--	--	--	01	02	.5
Agropyron repens	--	--	--	--	--	--	--	--	--	05
Agropyron spp.	--	--	03	--	--	--	--	--	--	--
Androsace chamaejasme	--	--	07	--	--	.5	--	--	.5	07
Anemone parviflora	--	--	.5	--	--	.5	--	.5	.5	.5
Antennaria lanata	--	--	01	--	--	05	--	03	--	02
Arctostaphylos uva-ursi	--	07	--	15	03	--	03	--	--	06
Aster conspicuus	03	--	--	--	--	--	--	--	--	--
Carex atrosquama	--	--	02	--	--	--	--	--	--	--
Carex aerantica	05	--	--	--	--	--	--	--	--	--
Carex rupestris	--	--	05	--	--	--	--	--	--	--
Carex spp.	--	02	--	02	--	--	--	--	--	--
Cerastium arvense	.5	04	--	--	--	--	.5	--	--	--
Danthonia intermedia	--	10	--	--	02	--	--	--	10	--
Delphinium glaucum	05	03	--	--	--	--	.5	--	01	--
Deschampsia caespitosa	05	01	--	--	--	--	--	10	.5	--
Elymus innovatus	15	10	02	--	--	--	30	--	05	02
Erigeron peregrinus	--	--	02	--	--	--	--	01	--	--
Festuca saximontana	--	.5	--	--	--	--	--	.5	--	02
Fragaria virginiana	05	--	--	01	--	--	02	--	05	03
Gallium boreale	02	03	--	--	.5	--	01	--	--	--
Gentiana amarella	--	--	.5	--	--	--	.5	.5	01	--
Gentiana propinqua	--	--	--	--	.5	.5	--	--	--	--
Geum triflorum	.5	06	--	--	--	.5	--	--	--	--
Hedysarum alpinum	--	10	--	.5	--	--	01	05	.5	04
Hedysarum sulphurescens	--	--	01	--	10	05	--	--	--	--
Kobresia myosuroides	10	20	05	12	50	45	13	35	45	30
Oxytropis campestris	--	03	--	--	.5	--	--	--	--	--
Oxytropis deflexa	--	02	--	--	--	--	--	--	01	03
Phyllodoce glanduliflora	--	--	02	--	--	--	--	--	--	--
Poa nervosa	--	--	05	--	--	--	--	--	--	--
Poa spp.	--	02	--	01	--	--	.5	--	--	05
Polygonum viviparum	--	01	--	.5	--	.5	--	.5	--	.5
Potentilla diversifolia	--	.5	01	--	03	--	--	--	--	--
Potentilla fruticosa	--	03	--	--	--	--	--	--	--	--
Rubus acaulis	.5	--	--	.5	--	--	--	--	.5	.5
Salix nivalis	--	--	03	--	--	--	--	--	--	--
Solidago multiradiata	--	--	--	.5	--	--	--	--	--	02
Trisetum spicatum	.5	--	.5	--	--	--	--	--	--	03
Valeriana septentrionalis	10	--	--	.5	--	--	01	--	--	02
BRYOID LAYER										
Brachythecium spp.	--	--	--	.5	--	.5	--	--	--	.5
Campylium stellatum	--	--	--	--	--	.5	--	15	--	--
Cetraria ericetorum	--	.5	.5	04	--	--	.5	--	.5	--
Cetraria nivalis	--	--	02	01	--	--	--	--	--	--
Cladonia pyxidata	--	--	--	--	--	--	--	--	.5	.5
Cladonia squamosa	--	01	--	--	--	--	.5	--	--	--
Distichium capillaceum	--	--	--	.5	--	--	--	.5	--	--
Ditrichum flexicaule	--	--	--	--	--	.5	--	.5	--	--
Peltigera canina	--	.5	--	--	--	--	.5	--	--	--
Peltigera rufescens	--	--	.5	01	--	--	--	--	.5	01
Rinodina roscida	--	--	.5	--	--	--	--	--	.5	--
Thuidium abietinum	.5	--	.5	--	--	.5	.5	.5	.5	01
Tomenthypnum nitens	--	--	--	--	--	--	--	25	--	--
Tortula ruralis	05	--	08	--	--	--	01	--	.5	01

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The S9 v.t. is successionally mature.

The S9 v.t. is distinguished from other v.t.s with the same shrub dominants (S1, S4, S10, S11) by the dominance of *Kobresia myosuroides* in the herb layer and by the coarser soil textures.

Other Studies: Descriptions of similar types by other authors were not found.

S10: ***Salix glauca-Betula glandulosa-Potentilla fruticosa***

(willow-dwarf birch-shrubby cinquefoil)

Environment: The S10 v.t. occurs on mesic to subxeric, Lower to Upper Subalpine sites (1900-2350 m: B; 1750-2200 m J) on moderate to steep slopes of southerly and westerly aspect, primarily in eastern Banff and eastern and northern Jasper. The soils are well to rapidly drained Brunisols and Regosols. The landforms are mostly colluvial with some fluvial and morainal landforms. The sites are commonly snow avalanched.

Vegetation: Total shrub cover (Plate 58) is typically 30 to 70% with *Salix glauca* (15-40%) dominant (Table 68). *Betula glandulosa* (10-35%) is codominant to dominant, or sometimes absent. *Potentilla fruticosa* (1-3%) and *Juniperus communis* (1-10%) are often present. Scattered *Picea engelmannii* and *Abies lasiocarpa* trees are sometimes present but usually with <5% cover. Total herb-dwarf shrub cover is 40 to 60% with *Arctostaphylos uva-ursi* (10-20%) and *Elymus innovatus* (10-20%) often dominant. Other important species are *Epilobium angustifolium* (1-5%), *Fragaria virginiana* (2-5%), and, in Banff, *Hedysarum sulphurescens* (1-5%). Common species with low cover include *Achillea millefolium, Agoseris glauca* (Banff), *Delphinium glaucum, Potentilla diversifolia, Solidago multiradiata, Poa* spp., and *Zygadenus elegans.* Bryoid cover is low (<10%) with *Tortula ruralis* and *Peltigera* spp. most common.

Table 68 Stands representing the willow-dwarf birch-shrubby cinquefoil (S10) v.t.

	IC	IC	JC	JD	JE	LC	PA	PA	SJ	SJ
	60	60	60	80	80	90	80	91	80	80
	17	58	78	97	68	74	74	15	35	39
SHRUB LAYER										
Betula glandulosa	30	55	30	40	--	20	--	--	--	10
Juniperus communis	04	02	07	--	01	15	.5	.5	--	03
Potentilla fruticosa	01	03	02	.5	--	15	--	--	08	12
Salix glauca	30	03	08	30	30	16	25	50	20	04
Shepherdia canadensis	03	--	18	--	--	.5	--	--	--	03
HERB-DWARF SHRUB LAYER										
Achillea millefolium	.5	--	01	01	02	--	.5	01	02	01
Agoseris glauca	--	--	--	02	.5	--	.5	.5	--	--
Androsace chamaejasme	--	.5	--	.5	--	--	--	--	02	01
Arctostaphylos uva-ursi	10	25	20	10	02	05	--	10	06	23
Astragalus alpinus	.5	--	--	--	--	--	01	01	02	--
Carex spp.	02	01	--	01	.5	--	--	--	.5	04
Delphinium glaucum	--	--	--	.5	02	--	--	.5	02	--
Elymus innovatus	01	10	30	20	25	20	20	30	07	10
Epilobium angustifolium	--	--	01	01	.5	05	03	05	--	--
Fragaria virginiana	.5	01	04	10	04	05	--	05	05	04
Hedysarum sulphurescens	--	--	--	08	05	--	20	--	--	--
Poa spp.	--	--	--	10	02	--	--	--	05	05
Potentilla diversifolia	--	--	--	--	.5	--	--	.5	10	.5
Solidago multiradiata	--	--	--	.5	.5	--	01	--	.5	--
Zygadenus elegans	01	01	--	--	--	03	.5	--	--	--
BRYOID LAYER										
Peltigera spp.	--	--	.5	.5	--	--	25	10	--	--
Tortula ruralis	--	--	.5	05	--	--	--	--	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The S10 v.t. is mature successionally.

The S10 v.t. differs from S4, S8 and S12 in being drier as indicated by the absence of gleyed soils, the absence or very low cover of *Salix barrattiana, Trollius albiflorus,* and *Erigeron peregrinus,* and the presence of

Arctostaphylos uva-ursi in most S10 stands. Intergrades between S10 and S4 or S12 occur.

Other Studies: Descriptions of similar types by other authors were not found.

S11: *Salix glauca/Danthonia intermedia*

(willow/timber oatgrass)

Environment: The S11 v.t. occurs on hygric to mesic sites on nearly level to gentle slopes of various aspects. In Banff, S11 occurs in the Upper Subalpine (1850-2200 m) throughout the park, while in Jasper it occurs in the Lower Subalpine (1400-1750 m) with nearly all stands north of Highway 16. The soils include Gleysols, Regosols, and Brunisols on fluvial landforms. Soil drainage is mostly moderately well to imperfectly drained, but varies from well to poorly drained. The wide range of moisture regime, soil drainage and soil taxa suggests a fluctuating water table in these sites.

Vegetation: *Salix glauca* (10-45%) is the dominant shrub with lesser amounts of *Betula glandulosa* (5-15%) and *Potentilla fruticosa* (5-20%) (Table 69). *Salix farrae* and *Salix barrattiana* also occur with low cover. Total shrub cover is 30 to 80%. The dense herb-dwarf shrub layer (60-90%) is dominated by *Danthonia intermedia* (10-40%) (Plate 59). Other important species are *Fragaria virginiana* (5-20%), *Phleum alpinum* (1-5%), *Trisetum spicatum* (1-3%), *Potentilla diversifolia* (1-3%), *Achillea millefolium* (1-2%), and *Valeriana sitchensis* (1%). Common species with <1% cover include *Epilobium angustifolium*, *Poa alpina*, *Carex* spp. (especially *Carex scirpoidea*), *Polygonum viviparum*, *Sibbaldia procumbens*, and *Aster ciliolatus*. Herbs are much more important than dwarf shrubs and species richness is high. Bryoid cover is variable but usually <30%. Species occurrence also varies, but the mosses *Tortula ruralis*, *Aulacomnium palustre*, *Polytrichum juniperinum*, and *Tortula norvegica* are most common. Lichen cover is usually <1%.

The S11 v.t. is mature successionally.

The S11 v.t. is distinguished from other v.t.s in which *Salix glauca* is important, primarily by the dominance of *Danthonia intermedia* in the herb-dwarf shrub layer. In S1, *Betula glandulosa* is usually dominant and the dense bryoid layer is dominated by *Tomenthypnum nitens*. The herb-dwarf shrub layer in S4 is dominated by *Erigeron peregrinus* and contains little, if any, *Danthonia intermedia*. *Kobresia myosuroides* is the dominant herb in S9, although intergrades between S9 and S11 occur. S10 occurs on steeper, drier sites than S11, as evidenced by the lack of gleyed soils and frequent dominance of *Arctostaphylos uva-ursi* in the herb-dwarf shrub layer. *Elymus innovatus* is the dominant herb in S12, although the two v.t.s have many other features in common.

Table 69 Stands representing the willow / timber oatgrass (S11) v.t.

	JD	KS	KS	KS	LC	PA	PA	PA	PA	PA
	71	60	60	60	90	71	71	71	80	81
	67	87	88	94	33	63	71	72	86	70
SHRUB LAYER										
Betula glandulosa	15	--	01	--	15	10	10	--	05	--
Potentilla fruticosa	10	--	05	15	--	10	10	10	.5	10
Salix barrattiana	05	--	--	--	--	--	10	--	10	.5
Salix glauca	10	60	55	60	20	15	25	25	35	15
HERB-DWARF SHRUB LAYER										
Achillea millefolium	.5	.5	03	02	01	01	.5	02	.5	--
Aster ciliolatus	.5	--	.5	--	--	--	.5	.5	--	03
Carex spp.	.5	.5	06	.5	01	--	02	02	10	--
Danthonia intermedia	70	20	10	20	20	35	30	40	30	65
Epilobium angustifolium	--	10	.5	.5	10	--	--	--	--	--
Erigeron peregrinus	.5	--	--	--	--	--	02	.5	10	--
Fragaria virginiana	05	10	20	10	05	10	--	10	05	--
Gentiana amarella	--	.5	.5	01	--	01	--	--	--	--
Phleum alpinum	01	01	06	08	--	--	.5	01	--	.5
Poa spp.	04	.5	05	--	--	.5	.5	02	--	.5
Polygonum viviparum	.5	--	.5	--	--	--	.5	--	01	02
Potentilla diversifolia	.5	--	--	--	--	01	05	.5	03	05
Sibbaldia procumbens	01	08	--	--	--	--	--	.5	--	.5
Trisetum spicatum	03	03	03	03	--	.5	02	05	--	--
BRYOID LAYER										
Aulacomnium palustre	05	--	--	--	--	--	--	--	--	--
Cladonia spp.	03	--	--	--	--	.5	--	.5	05	--
Polytrichum juniperinum	--	20	--	.5	15	--	--	.5	--	--
Tortula norvegica	--	20	--	20	--	15	--	--	15	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Other Studies: A similar type (*Salix glauca*) was described by Ogilvie (1976) for the Alberta Rocky Mountains.

S12: *Salix glauca/Elymus innovatus*

(willow/hairy wild rye)

Environment: The S12 v.t. occurs on mesic to subhygric, Lower to Upper Subalpine sites (1800-2300 m B; 1500-2050 m J) on various slopes of mostly southerly and westerly aspect. The soils are well to imperfectly drained Orthic Eutric Brunisols, Regosols, and Humic Regosols. The landforms are predominantly fluvial, with some colluvial and morainal landforms.

Vegetation: *Salix glauca* (30-60%) is the dominant shrub with lesser amounts of *Betula glandulosa* (5-15%) and other *Salix* spp. (Table 70). Total shrub cover is 30 to 75% (Plate 60). *Elymus innovatus* (20-40%) dominates the herb-dwarf shrub layer. Total layer cover is 40 to 90% with herbs much more important than dwarf shrubs. Other common species, generally with 1 to 3% cover, include *Fragaria virginiana*, *Achillea millefolium*, *Astragalus alpinus*, *Delphinium glaucum*, *Epilobium angustifolium*, *Potentilla diversifolia*, *Equisetum scirpoides*, and *Poa* spp.. Bryoid cover is low (<25%) with *Tortula ruralis*, *Tortula norvegica*, *Cladonia pyxidata*, *Peltigera rufescens*, and *Ceratodon purpureus* most common.

Table 70 Stands representing the willow / hairy wild rye (S12) v.t.

	1C 80 77	1C 80 79	JC 80 76	JD 80 63	JD 80 64	JD 90 64	JD 90 86	JE 80 31	PA 81 18	PA 91 16
SHRUB LAYER										
Betula glandulosa	--	--	25	--	--	01	--	05	--	--
Juniperus communis	--	--	--	--	.5	--	.5	--	--	--
Salix glauca	33	45	60	70	90	60	60	40	30	60
Salix spp.	02	--	--	05	.5	--	--	--	.5	10
HERB-DWARF SHRUB LAYER										
Achillea millefolium	.5	01	01	05	--	.5	05	.5	05	01
Agoseris glauca	--	.5	--	02	.5	--	.5	.5	--	02
Antennaria nitida	--	.5	--	.5	.5	.5	.5	--	--	--
Astragalus alpinus	02	05	01	03	02	--	--	--	05	--
Carex spp.	.5	01	--	--	.5	01	--	.5	03	04
Danthonia intermedia	--	15	--	.5	--	--	04	--	03	--
Delphinium glaucum	02	03	01	02	--	.5	.5	.5	02	05
Elymus innovatus	35	25	35	20	30	25	40	20	30	25
Epilobium angustifolium	05	--	--	20	.5	.5	01	03	05	02
Equisetum scirpoides	.5	04	02	--	01	--	--	--	.5	--
Erigeron peregrinus	--	--	--	10	01	--	01	.5	05	.5
Festuca saximontana	--	01	.5	--	.5	--	--	--	.5	01
Fragaria virginiana	03	01	.5	--	--	02	05	.5	01	05
Gentiana amarella	--	.5	--	01	--	.5	--	--	.5	--
Poa spp.	--	05	--	01	.5	01	05	--	--	.5
Polygonum viviparum	--	--	--	--	.5	--	--	--	.5	--
Potentilla diversifolia	--	--	--	02	.5	--	01	.5	02	.5
Solidago multiradiata	--	--	--	.5	10	01	--	.5	.5	01	.5
Trisetum spicatum	01	--	--	01	--	--	02	--	10	.5
Valeriana sitchensis	--	--	--	.5	--	.5	05	.5	--	--	05
BRYOID LAYER										
Ceratodon purpureus	.5	.5	--	--	--	.5	--	--	--	--	--
Cetraria ericetorum	.5	--	--	.5	--	.5	--	--	--	--	--
Cladonia spp.	.5	--	.5	03	23	.5	.5	01	.5	.5
Peltigera aphthosa	.5	--	--	01	01	--	.5	--	--	--
Tortula norvegica	.5	.5	--	--	--	--	--	--	--	--
Tortula ruralis	--	--	--	--	--	--	--	.5	.5	25

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The S12 v.t. is mature successionally. Occasional stands contain scattered trees (<5% cover) but succession to forest appears unlikely.

The S12 v.t. is differentiated from the similar S4 by having >10% cover of *Elymus innovatus*, by the absence or low cover of *Salix barrattiana*, and by lower cover of *Betula glandulosa*. S10 is drier than S12, being typically mesic to subxeric, well to rapidly drained, without gleyed soils and frequently containing *Arctostaphylos uva-ursi*. *Salix barrattiana* dominance separates S8 from S12. Intergrades between S12 and S4, S8 or S10 occur.

Other Studies: In Banff, a similar type has been described by Beder (1967, *Salix glauca*). Hettinger (1975, *Salix glauca/Elymus innovatus*) and Crack (1977, *Salix glauca*) have described similar types in Jasper.

L1: *Potentilla fruticosa/Arctostaphylos uva-ursi-Galium boreale*

(shrubby cinquefoil / bearberry-northern bedstraw)

Environment: The L1 v.t. occurs on subxeric to xeric, Montane to Lower Subalpine (1050 - 2170 m) steeply sloping sites of southerly exposure in Banff and Jasper. The soils are rapidly to well drained Orthic and Orthic Humic Regosols developed on colluvial, eolian and glacial landforms.

Vegetation: *Potentilla fruticosa* is the dominant shrub with generally <15% (Table 71) cover. *Juniperus communis* (<5%) is also usually present with total shrub cover generally <15% (Plate 61). The herb-dwarf shrub layer is well developed with cover 25 to 80%. *Arctostaphylos uva-ursi* (10-55%) is dominant with lesser amounts of *Galium boreale* (<3%), *Artemisia frigida* (<5%), *Anemone multifida* (<2%), *Koeleria cristata* (<5%), *Elymus innovatus* (<15%), and *Campanula rotundifolia* (<1%). *Agropyron spicatum* (<10%) occurs in some Banff stands. The bryoid layer has cover usually <1%.

Table 71 Stands representing the shrubby cinquefoil / bearberry / northern bedstraw (L1) v.t.

	1C 50 39	1C 80 90	1C 70 38	1C 90 18	JD 90 75	JN 70 08	JN 80 07	JN 80 25	PA 70 48	SJ 90 26
SHRUB LAYER										
Betula glandulosa	--	--	--	--	--	--	05	02	--	.5
Juniperus communis	05	.5	.5	02	--	01	.5	01	--	02
Juniperus horizontalis	--	--	--	--	10	--	--	--	--	--
Potentilla fruticosa	03	02	03	18	--	10	07	07	--	05
Rosa acicularis	01	--	--	.5	--	--	01	03	--	--
Shepherdia canadensis	.5	--	--	--	01	--	--	01	05	--
HERB-DWARF SHRUB LAYER										
Agropyron dasystachyum	.5	.5	.5	--	--	--	--	--	05	--
Androsace chamaejasme	--	--	--	--	.5	--	01	03	--	--
Androsace septentrionalis	.5	--	--	--	.5	--	--	--	--	.5
Anemone multifida	.5	--	02	01	03	.5	--	--	.5	--
Antennaria nitida	--	--	--	--	30	--	--	--	--	--
Arctostaphylos uva-ursi	.5	25	60	10	50	10	60	17	10	20
Artemisia frigida	.5	.5	.5	03	--	10	--	--	01	--
Artemisia michauxiana	--	--	.5	.5	--	05	--	--	--	--
Bryo humilis	--	--	--	--	--	--	--	--	--	02
Bromus pumpellianus	--	.5	.5	--	05	.5	--	--	--	--
Calamagrostis purpurascens	--	--	--	--	--	02	--	03	05	--
Calamagrostis spp.	--	--	--	--	--	--	07	--	--	--
Campanula rotundifolia	.5	.5	--	01	.5	--	--	--	--	--
Carex filifolia	--	01	--	--	--	02	--	--	--	--
Carex nigricans	--	--	--	--	--	--	.5	05	--	--
Carex scirpoidea	--	10	--	--	--	.5	01	01	--	--
Carex rupestris	--	--	--	--	01	--	--	--	05	06
Cerastium arvense	01	--	--	02	.5	--	--	--	--	--
Dryas integrifolia	--	--	--	--	--	--	03	02	--	08
Elymus innovatus	05	--	01	--	15	03	--	--	.5	--
Erigeron caespitosus	.5	--	01	--	--	.5	--	--	--	--
Fragaria virginiana	01	--	--	03	--	.5	--	--	--	--
Gaillardia aristata	.5	--	--	--	.5	05	--	--	.5	--
Galium boreale	.5	01	01	02	.5	02	03	01	--	--
Gentiana amarella	.5	--	--	01	--	--	--	.5	--	--
Gentiana propinqua	--	--	--	--	02	--	--	--	--	--
Hedysarum alpinum	--	--	--	.5	--	--	05	.5	--	.5
Hedysarum mackenzii	--	--	--	--	05	.5	--	--	--	--
Juniperus communis	--	--	--	--	--	--	--	--	10	--
Koeleria cristata	05	.5	02	05	05	.5	--	--	10	--
Linum lewisii	--	01	--	--	--	05	--	--	.5	--
Myosotis alpestris	--	--	--	--	--	--	--	--	--	03
Oxytropis splendens	.5	--	01	03	--	.5	--	--	--	--
Poa palustris	--	--	--	--	05	--	--	--	--	--
Potentilla fruticosa	--	--	--	--	05	--	--	--	07	--
Senecio cymbalarioides	--	.5	--	01	--	.5	--	--	--	--
Solidago decumbens	--	--	--	--	.5	--	--	--	03	--
Trisetum spicatum	--	--	--	--	03	--	--	--	--	--
Viola adunca	.5	--	--	01	--	--	--	--	--	01
Zygadenus elegans	--	--	--	--	--	.5	.5	01	--	03
BRYOID LAYER										
Hypnum vaucheri	.5	--	--	--	--	.5	--	--	--	--
Peltigera rufescens	.5	--	--	.5	--	--	--	--	--	--
Tortella tortuosa	.5	--	--	--	--	--	.5	--	--	--
Tortula ruralis	.5	--	--	.5	.5	--	--	--	--	--
Xanthoria elegans	--	.5	--	--	--	.5	--	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Successionally, L1 is mature, its treeless character being maintained by droughty, unstable soils.

On more stable slopes where forest cover is greater, stands transitional to C3 may occur. The L1 v.t. is distinguished from H14 by

having abundant *Potentilla fruticosa* and *Juniperus communis* and lesser amounts of *Elymus* and *Koeleria*. Stands transitional between L1 and H14 occur.

Other Studies: Similar types have been described by Douglas (1974) for the southern Yukon (*Juniperus communis-Arctostaphylos uva-ursi*), in Jasper by Hettinger (1975, *Arctostaphylos uva-ursi-Calamagrostis purpurascens*), and Kuchar (1972, dry shrubby slope). The "steep herb-covered slopes" described by Jeffrey et al. (1968) in southwestern Alberta are also similar.

L2: *Juniperus communis-Salix glauca*

(juniper-willow)

Environment: The L2 v.t. occurs on subxeric, mostly Upper Subalpine sites (1900-2250 m) on steep slopes of southerly aspect. The soils are rapidly to well drained Orthic Regosols, Humic Regosols and Eutric Brunisols on colluvial landforms. The sites are commonly snow avalanched.

Table 72 Stands representing the juniper-willow (L2) v.t.

	1C 50 24	1C 90 54	JC 60 49	JC 60 79	JD 50 92	JR 81 64	LC 91 08	PA 70 61	PA 90 95	SJ 90 55
SHRUB LAYER										
Betula glandulosa	01	03	--	01	--	--	--	--	--	10
Juniperus communis	01	10	30	12	20	10	10	20	10	10
Potentilla fruticosa	--	01	--	03	--	--	--	--	--	05
Rosa acicularis	02	--	04	--	01	--	--	--	--	.5
Salix glauca	10	30	12	10	10	--	10	.5	--	04
Shepherdia canadensis	--	05	--	03	--	--	.5	.5	--	--
HERB-DWARF SHRUB LAYER										
Achillea millefolium	.5	.5	--	01	.5	01	--	--	--	--
Anemone multifida	--	--	--	--	--	--	--	--	01	--
Anemone parviflora	--	--	--	--	--	--	--	--	--	.5
Antennaria alpina	--	.5	--	--	--	--	--	--	--	--
Antennaria nitida	--	--	--	--	.5	.5	--	--	--	--
Antennaria racemosa	--	--	--	--	05	--	04	--	--	--
Antennaria rosea	--	--	--	--	--	--	--	.5	--	--
Antennaria umbrinella	--	--	.5	--	--	--	--	--	--	--
Aquilegia flavescens	--	--	--	--	.5	--	02	--	--	.5
Arabis holboellii	--	--	--	--	--	--	.5	--	--	--
Arabis lyallii	--	--	--	--	--	--	--	.5	--	--
Arctostaphylos uva-ursi	10	09	15	45	10	08	--	20	05	15
Arenaria capillaris	--	--	--	--	.5	--	--	--	--	--
Arnica alpina	--	--	--	--	--	--	03	--	--	--
Artemisia norvegica	01	--	02	--	--	--	--	--	--	--
Astragalus alpinus	--	--	--	--	01	--	--	--	.5	--
Astragalus frigidus	--	--	--	--	01	--	--	--	--	--
Bromus pumpellianus	--	--	--	--	01	--	--	--	--	--
Calamagrostis inexpansa	--	--	--	--	--	.5	--	--	--	--
Calamagrostis purpurascens	--	--	--	--	--	--	--	01	--	--
Campanula lasiocarpa	.5	--	--	--	--	--	--	--	--	--
Campanula rotundifolia	--	--	--	--	05	--	--	--	--	--
Carex concinna	--	.5	--	--	--	--	.5	--	--	02
Carex spp.	--	.5	--	--	--	.5	.5	--	.5	04
Elymus innovatus	02	02	02	35	--	--	--	03	25	02
Epilobium angustifolium	03	.5	.5	--	01	.5	--	--	.5	--
Festuca saximontana	.5	--	.5	--	01	01	--	--	--	--
Fragaria virginiana	--	.5	--	--	.5	01	03	--	.5	.5
Saxifraga bronchialis	.5	--	01	--	.5	.5	--	--	--	--
Solidago multiradiata	01	--	--	--	01	01	--	--	03	--
Zygadenus elegans	--	--	01	--	--	--	03	02	10	08
Selaginella dense	--	.5	01	--	.5	--	--	--	--	.5
BRYOID LAYER										
Cladonia spp.	.5	.5	--	--	--	.5	.5	--	--	--
Peltigera spp.	--	.5	--	--	--	.5	.5	--	--	.5
Tortella tortuosa	--	--	--	--	--	--	.5	.5	--	--
Tortula ruralis	--	--	--	--	--	--	--	.5	--	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: The shrub layer (Plate 62) is moderately dense (20-40%) and dominated by *Juniperus communis* (10-25%) and *Salix glauca* (10-25%). *Potentilla fruticosa*, *Rosa acicularis*, and *Shepherdia canadensis* also occur frequently (Table 72). The herb-dwarf shrub layer has a total cover of 40 to 80% with *Arctostaphylos uva-ursi* (10-25%) dominant. Other important species with 1 to 3% cover, are *Fragaria virginiana*, *Elymus innovatus*, and *Epilobium angustifolium*. *Achillea millefolium*, *Saxifraga bronchialis*, *Trisetum spicatum*, *Zygadenus elegans*, and *Linnaea borealis* occur frequently but with low cover. Bryoid cover is low (<10%) and sporadic.

Occasional trees of *Picea engelmannii* and regeneration of *Picea engelmannii* and *Abies lasiocarpa* occur in L2 stands, but avalanche activity appears to prevent development of a forest. Thus, L2 is regarded as mature successionally.

The L2 v.t. has similarities to S10 but is separated by the dominance in L2 of *Juniperus communis* and lesser cover values of *Betula glandulosa* and *Potentilla fruticosa*. Intergrades between the two v.t.s occur.

Other Studies: Kuchar (1978) described a similar type (deciduous avalanche scrub) in Yoho National Park, British Columbia.

L4: *Cassiope tetragona-Dryas octopetala-Salix nivalis*

(white mountain heather-mountain avens-snow willow)

Environment: The L4 tundra occurs on mesic to subhygric, predominantly Alpine (2040-2460 m J, 2160-2460 m B) gently to steeply sloping sites of predominantly northerly aspect throughout Banff and Jasper. Soils are well to moderately well drained Eutric and Dystric Brunisols, Melanic and Sombric Brunisols and Regosols, developed on morainal and colluvial landforms.

Vegetation: Trees are absent (Plate 63) except for occasional *Picea engelmannii* and *Abies lasiocarpa* krummholz and tree islands at the lower elevational limit. Shrubs are usually absent. Total heather cover is 10 to 50% with lesser amounts of *Phyllodoce glanduliflora* (<15%) and occasionally *Phyllodoce empetriformis* (Table 73). *Dryas octopetala* (10-35%) and *Salix nivalis* (<45%) are codominant and lesser amounts of *Polygonum viviparum* (<1%), *Potentilla diversifolia* (1%), *Silene acaulis* (<5%), *Castilleja occidentalis* (<1%), and *Salix arctica* (<15%) are present. Total herb-dwarf shrub cover is 25 to 85%. The bryoid layer has low to moderate cover (10-40%) with much of the cover attributable to species with sporadic occurrence. Characteristic species are *Dicranum scoparium* (<2%), *Cetraria islandica* (<5%),

Cetraria nivalis (<3%), other *Cetraria* species, and *Stereocaulon alpinum* (<3%).

Table 73 Stands representing the white mountain heather-mountain avens-snow willow (L4) v.t.

	1C	1C	1C	2C	2D	2E	2H	8S	PA	PA
	60	60	90	60	80	91	70	50	71	80
	20	30	23	70	99	83	80	99	19	84
HERB-DWARF SHRUB LAYER										
Anemone drummondii	--	.5	--	--	--	--	--	01	--	--
Anemone parviflora	--	--	--	.5	--	--	.5	--	--	--
Antennaria lanata	01	--	--	--	08	--	--	--	--	--
Arenaria obtusiloba	--	--	--	--	--	--	--	.5	.5	--
Arenaria rubella	--	--	.5	--	--	--	--	--	--	--
Artemisia norvegica	--	--	--	--	--	--	03	--	--	--
Campanula lasiocarpa	--	--	--	--	--	--	.5	--	--	--
Carex albo-nigra	--	--	--	01	--	.5	.5	--	--	--
Carex nardina	.5	--	--	--	--	.5	--	--	--	--
Carex scirpoidea	--	.5	--	--	--	--	.5	--	--	05
Cassiope tetragona	90	60	30	35	60	05	10	30	15	35
Castilleja occidentalis	.5	--	.5	--	--	.5	02	.5	.5	.5
Dryas octopetala	12	15	12	60	15	20	15	20	15	15
Equisetum scirpoides	--	--	01	.5	--	--	--	--	--	--
Erigeron aureus	--	--	--	--	.5	.5	--	03	01	01
Festuca brachyphylla	--	--	--	--	--	--	--	02	.5	--
Festuca saximontana	--	--	--	--	01	.5	--	--	--	--
Luzula spicata	--	--	--	--	.5	.5	--	.5	.5	--
Phyllodoce glanduliflora	35	01	--	--	20	08	05	08	02	05
Poa alpina	01	--	.5	.5	--	.5	--	--	--	.5
Poa sp.	--	--	01	--	.5	--	--	.5	--	--
Polygonum viviparum	--	.5	.5	--	.5	.5	.5	--	--	05
Potentilla diversifolia	.5	--	.5	--	01	.5	05	--	.5	.5
Salix arctica	--	--	08	05	02	--	02	--	--	--
Salix nivalis	06	08	10	03	10	03	07	02	05	03
Sedum stenopetalum	.5	--	--	--	.5	--	--	--	--	--
Selaginella densa	01	.5	--	--	.5	.5	--	01	.5	--
Sibbaldia procumbens	.5	--	--	--	.5	.5	--	.5	--	--
Silene acaulis	.5	02	--	02	.5	.5	02	--	01	08
Solidago multiradiata	--	--	--	--	.5	--	.5	--	--	.5
Trisetum spicatum	--	--	01	--	.5	.5	.5	.5	--	--
BRYOID LAYER										
Cetraria cucullata	--	--	.5	--	--	.5	--	--	01	--
Cetraria ericetorum	--	--	--	--	.5	02	--	.5	--	--
Cetraria islandica	--	--	01	--	01	.5	.5	01	01	05
Cetraria nivalis	--	--	--	--	01	.5	.5	.5	--	--
Cladonia carneola	--	--	--	--	--	--	.5	.5	--	--
Cladonia ecmocyna	--	--	--	--	--	.5	--	03	--	--
Cladonia mitis	--	--	.5	--	--	.5	--	--	--	--
Cladonia pyxidata	--	--	--	--	--	.5	.5	--	--	01
Cladonia spp.	--	--	--	--	--	05	.5	--	.5	--
Dactylina arctica	--	--	--	--	--	--	--	.5	.5	--
Dactylina ramulosa	--	--	--	--	--	.5	--	--	.5	--
Dicranum muehlenbeckii	--	--	--	--	.5	.5	--	--	--	--
Dicranum scoparium	--	--	05	06	.5	--	.5	02	.5	--
Distichium capillaceum	--	.5	--	--	--	--	--	--	--	01
Drepanocladus uncinatus	--	--	05	01	--	--	--	--	--	--
Hylocomium splendens	--	--	15	03	--	--	--	--	--	--
Hypnum revolutum	--	--	--	.5	--	--	--	--	.5	--
Kiaeria sp.	--	--	03	--	--	--	--	--	--	--
Peltigera aphthosa	--	--	--	.5	01	--	.5	--	--	--
Peltigera rufescens	--	--	--	--	.5	.5	--	--	--	--
Polytrichum piliferum	--	--	--	--	.5	.5	.5	10	--	--
Rhizocarpon geographicum	--	--	--	--	--	02	--	--	01	--
Stereocaulon alpinum	--	--	01	--	.5	.5	--	.5	--	--
Stereocaulon tomentosum	--	--	--	--	--	--	02	30	--	--
Thamnolia subuliformis	--	--	--	--	--	.5	--	02	--	--
Tortella fragilis	--	--	--	--	--	.5	.5	--	--	01
Tortula ruralis	--	--	--	--	--	.5	.5	--	--	.5
Umbilicaria hyperborea	--	--	--	--	--	03	--	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The L4 v.t. is successionally mature.

The L4 v.t. is distinguished by the dominance of *Cassiope tetragona* and occurs in association with H1, in depressions with greater snow accumulation than the more wind swept H1. Areas of transition to L5 may occur in snow accumulation areas where *Phyllodoce glanduliflora* and *Cassiope mertensiana* replace *Cassiope tetragona*. Stands which are transitional to O10 or C23 occur near the lower elevational limit.

Other Studies: Similar types have been described for Alberta by Mortimer (1978) for the northern Front Ranges *(Dryas integrifolia-Cassiope tetragona, Cassiope tetragona-Dryas octopetala)*, Ogilvie (1976) in the Alberta Rockies, and for the Kananaskis area, Trottier (1972), Jacques and Legge (1974), and Kondla (1978, Cassiope heath). Similar types in Jasper have been described by Hrapko and La Roi (1978, *Cassiope tetragona-Dryas octopetala*), Kuchar (1975, *Cassiope tetragona/Dryas octopetala*), La Roi (1975, *Cassiope tetragona/Dryas octopetala/Cetraria islandica*), and Crack (1977, *Cassiope tetragona*). In Banff, similar types have been described by Broad (1973, *Cassiope mertensiana*), Knapik et al. (1973, *Cassiope tetragona*), and Beder (1967, *Cassiope tetragona*). Kuchar (1978) described similar vegetation for Yoho National Park (four-angled mountain heather-white dryad heath tundra), and Choate and Habeck (1967) described similar vegetation at Logan Pass, Glacier National Park, Montana.

L5: ***Phyllodoce glanduliflora-Cassiope mertensiana-Antennaria lanata***

(heather-everlasting)

Environment: The L5 heather tundra occurs on mesic predominantly Alpine (2000-2380 m J, 2130-2530 m B), level to steeply sloping sites of various aspects in western Banff and Jasper. Soils are well to moderately well drained Eutric and Dystric Brunisols, Orthic Humo-Ferric Podzols, and Melanic and Sombric Brunisols developed on morainal and residual landforms.

Vegetation: Trees are absent (Plate 64) except for occasional *Picea engelmannii* and *Abies lasiocarpa* krummholz and tree islands at the lower elevational limits. Total heath cover is 20 to 75%, dominated by *Phyllodoce glanduliflora* (10-50%) and *Cassiope mertensiana* (10-70%) with lesser amounts of *Phyllodoce empetriformis* (<30%) and *Cassiope tetragona* (<10%) (Table 74). Other characteristic species include *Antennaria lanata* (2-15%), *Salix arctica* (<15%), *Sibbaldia procumbens* (<5%), *Potentilla diversifolia* (<1%), *Erigeron peregrinus* (<2%), *Luzula wahlenbergii* (1%), and in Jasper, *Artemisia norvegica* (<5%). Cover of the herb-dwarf shrub layer is 40 to 90%. Bryoid cover however, is generally low (<25%), the most abundant mosses being *Dicranum scoparium* (<10%) and *Polytrichum juniperinum* (<3%) with total moss cover 5 to 25%. Lichen cover is also low (<10%) with common species being *Cladonia ecmocyna* (<3%) and *Cetraria islandica* (<2%).

The L5 v.t. is successionally mature.

Some stands may be transitional to L4 where *Cassiope tetragona* and *Dryas octopetala* replace *Phyllodoce glanduliflora* and *Cassiope mertensiana*. Stands also occur which are transitional to C23 and O10 where trees are at their upper elevational limits.

Table 74 Stands representing the heather-everlasting (L5) v.t.

	AM	IC	JC	JD	JE	JM	KE	LC	PA	SJ
	51	61	60	70	90	80	30	91	71	90
	04	31	94	14	79	57	57	34	25	84
SHRUB LAYER										
Abies lasiocarpa	08	--	--	--	--	03	--	--	--	--
HERB-DWARF SHRUB LAYER										
Anemone occidentalis	--	--	02	--	--	--	.5	--	--	--
Antennaria lanata	.5	05	01	--	08	02	30	13	05	05
Antennaria umbrinella	--	--	.5	.5	--	--	--	--	--	--
Artemisia norvegica	--	01	01	--	--	01	--	05	--	--
Carex nardina	--	--	--	.5	--	--	--	03	--	--
Carex scirpoidea	--	--	--	.5	--	--	--	02	--	--
Carex spp.	.5	.5	--	--	01	.5	--	--	--	--
Cassiope mertensiana	85	01	20	86	25	30	15	15	15	65
Castilleja occidentalis	--	.5	.5	--	--	.5	--	--	--	--
Dryas octopetala	--	04	--	--	--	.5	--	--	--	--
Erigeron peregrinus	.5	01	03	--	--	--	--	--	--	--
Gentiana glauca	--	.5	--	--	.5	--	--	.5	--	.5
Juncus drummondii	--	--	--	.5	--	.5	.5	--	--	--
Luzula spicata	--	--	.5	--	--	--	--	--	--	03
Luzula wahlenbergii	.5	--	--	--	01	--	.5	02	--	--
Myosotis alpestris	--	--	--	--	--	.5	--	--	--	01
Pedicularis bracteosa	.5	--	01	.5	--	05	--	--	--	--
Phyllodoce empetriformis	--	--	--	--	--	--	--	--	--	10
Phyllodoce glanduliflora	07	35	45	30	15	40	40	05	45	10
Poa alpina	--	03	01	.5	--	--	.5	.5	--	--
Poa cusickii	--	--	02	--	--	--	--	--	--	02
Polygonum viviparum	--	.5	.5	--	.5	.5	--	--	--	--
Potentilla diversifolia	--	01	02	.5	--	.5	.5	--	--	--
Ranunculus eschscholtzii	--	--	--	.5	--	02	.5	--	--	--
Salix arctica	01	02	15	--	10	--	05	10	--	--
Salix nivalis	--	08	03	05	--	.5	--	--	05	--
Sibbaldia procumbens	--	.5	.5	.5	.5	.5	03	01	--	.5
Silene acaulis	--	--	.5	--	--	.5	.5	--	.5	--
Trollius albiflorus	--	--	--	--	--	04	--	--	--	--
Vaccinium scoparium	01	--	--	--	--	.5	--	--	05	--
Valeriana sitchensis	--	--	--	.5	--	02	--	--	--	--
Selaginella densa	--	.5	04	--	--	--	05	--	01	--
BRYOID LAYER										
Brachythecium spp.	--	--	--	--	--	35	--	--	--	--
Cetraria islandica	--	--	--	--	01	.5	--	.5	--	--
Cladonia mitis	--	--	--	--	02	.5	--	05	--	--
Cladonia coccifera	--	--	--	--	.5	--	--	02	--	--
Cladonia ecmocyna	--	--	--	--	.5	.5	--	01	--	--
Cladonia uncialis	--	--	--	--	01	--	--	05	--	--
Desmatodon latifolius	--	--	--	--	--	18	--	--	--	--
Dicranum elongatum	--	--	--	--	35	--	--	--	--	--
Dicranum scoparium	05	--	--	--	--	--	--	22	01	--
Distichium capillaceum	--	--	--	05	--	--	--	--	--	--
Lepraria neglecta	--	--	--	--	.5	--	--	01	--	--
Loharia linita	--	--	--	--	.5	.5	--	--	--	--
Ninium lycopodioides	--	--	--	03	--	--	--	--	--	--
Peltigera aphthosa	--	--	--	.5	.5	.5	--	--	--	--
Peltigera rufescens	--	--	--	--	.5	.5	--	--	--	--
Pohlia cruda	--	--	--	05	--	--	--	--	--	--
Polytrichum juniperinum	.5	--	03	--	10	.5	10	--	--	--
Polytrichum piliferum	--	--	--	--	--	--	--	02	--	.5
Pseudoleskea radicosa	--	--	.5	02	--	17	--	--	--	--
Rhizocarpon geographicum	--	--	--	--	.5	--	--	.5	03	--
Solorina crocea	--	--	--	--	.5	--	--	01	--	.5
Stereocaulon alpinum	--	--	--	--	03	--	--	05	--	--
Barbilophozia lycopodioides	--	--	.5	--	--	.5	--	--	01	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Other Studies: Numerous other workers have described types similar to L5. In Banff, similar types have been described by Trottier and Scotter (1973, *Phyllodoce* types), Broad (1973, *Phyllodoce*), Knapik et al. (1973, *Phyllodoce glanduliflora, Antennaria lanata*), and Beder (1967, *Phyllodoce glanduliflora-Vaccinium scoparium*). In Jasper, similar types have been described by Crack (1977, *Phyllodoce glanduliflora*), Hrapko and La Roi (1978, *Cassiope mertensiana-Phyllodoce glanduliflora*), Kuchar (1975, *Phyllodoce glanduliflora-Cassiope mertensiana*), and La Roi (1975, *Abies lasiocarpa/Cassiope mertensiana/Pseudoleskea radicosa*). Elsewhere in Alberta, Ogilvie (1976, *Phyllodoce*), Kondla (1978, everlasting-phyllodoce), Kirby and Ogilvie (1969, *Phyllodoce*), Mortimer (1978, *Phyllodoce glanduliflora-Cassiope mertensiana*), Jacques and Legge (1974, yellow heather), and Trottier (1972, *Phyllodoce*) have described similar types. In British Columbia, similar types have been described by Knapik and Landals (1974, *Cassiope mertensiana*) in Mount Revelstoke National Park and by Kuchar (1978, mountain heather tundra) in Yoho National Park.

L6: *Juniperus horizontalis-Agropyron dasystachyum-Carex scirpoidea*

(creeping juniper-northern wheatgrass-sedge)

Environment: The L6 shrubby grasslands occur on subxeric Montane (1010-1050 m), gently to moderately steeply sloping sites of generally southerly aspect in the Talbot Lake and east gate area of Jasper. Soils are rapidly to well drained, extremely calcareous, Orthic Regosols developed on eolian landforms.

Table 75 Stands representing the creeping juniper-wheatgrass-sedge (L6) v.t.

	JC	JE	KS
	70	90	60
	37	16	14
SHRUB LAYER			
Amelanchier alnifolia	--	--	.5
Elaeagnus commutata	--	.5	--
Juniperus communis	--	--	08
Juniperus horizontalis	20	30	02
Juniperus scopulorum	--	--	02
Potentilla fruticosa	02	.5	--
Rosa acicularis	--	.5	.5
Symphoricarpos albus	--	.5	.5
HERB-DWARF SHRUB LAYER			
Achillea millefolium	--	--	02
Agropyron dasystachyum	--	05	--
Agropyron inerme	10	--	--
Androsace septentrionalis	--	--	02
Antennaria rosea	--	--	15
Arabis holboellii	--	--	.5
Arctostaphylos uva-ursi	01	05	--
Artemisia frigida	01	01	--
Artemisia michauxiana	02	--	--
Astragalus decumbens	--	--	03
Astragalus striatus	--	--	10
Astragalus tenellus	--	03	--
Campanula rotundifolia	01	--	--
Carex scirpoidea	30	03	--
Carex umbellata	--	--	04
Erigeron compositus	--	--	10
Festuca saximontana	--	--	08
Gaillardia aristata	01	--	06
Galium boreale	--	--	04
Hedysarum mackenzii	02	01	--
Koeleria cristata	05	--	--
Linum lewisii	02	--	--
Senecio canus	--	--	10
Smilacina stellata	--	01	--
Stipa columbiana	--	--	15
BRYOID LAYER			
Barbula acuta	.5	--	--
Bryum argentium	--	.5	--
Campylium chrysophyllum	.5	--	--
Ditrichum flexicaule	.5	--	--
Hypnum cupressiforme	.5	--	--
Bryum spp.	--	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: The herb-dwarf shrub layer (Plate 65) has cover of 50 to 70% and is dominated by *Juniperus horizontalis* (20-30%) with lesser amounts of *Agropyron dasystachyum* (5-10%) and *Carex scirpoidea* (5-30%) (Table 75). Other species commonly present are *Potentilla fruticosa* (<5%), *Hedysarum mackenzii* (<5%), *Koeleria cristata* (<5%), *Arctostaphylos uva-ursi* (<5%), *Senecio cymbalarioides* (<1%), and *Carex richardsonii* (<1%). *Stipa comata* may occur locally. The bryoid layer has very low cover (<1%) with no dominants evident.

The L6 v.t. is successionally mature.

The L6 v.t. is distinguished from other v.t.s by the dominance of *Juniperus horizontalis* and the dry environment characterized by Regosolic, eolian soils. The L6 v.t. often occurs in association with dense *Picea glauca* thickets which occur in mesic depressions between the sand dunes on which the L6 v.t. usually occurs. The L6 v.t. also occurs in association with H6 and transitional stands may occur on sites with low *Juniperus horizontalis* cover. Stands with abundant *Agropyron dasystachyum* may be transitional to H7.

Other Studies: Descriptions of similar types by other authors were not found.

L7: *Salix arctica-Potentilla diversifolia*

(arctic willow-cinquefoil)

Environment: The L7 v.t. occurs on mesic to subhygric, Upper Subalpine to Alpine sites (2200-2440 m B; 1980-2390 m J) on various slopes and aspects. A variety of soils including Regosols, Humic Regosols, Dystric Brunisols, Gleysols, Orthic Sombric Brunisols, and Orthic Humo-Ferric Podzols occur. Drainage ranges from well to imperfect and the landforms are primarily morainal and fluvial. The L7 v.t. occurs in deep snow accumulation areas and often receives seepage much of the growing season.

Vegetation: The L7 v.t. is dominated by dwarf shrubs and herbs (Plate 66) including *Salix arctica* (10-35%), *Antennaria lanata* (5-20%), and *Potentilla diversifolia* (1-3%) (Table 76). Other important species include *Salix nivalis* (1-5%), *Phyllodoce glanduliflora* (1-5%), and *Castilleja occidentalis* (1-3%). *Erigeron peregrinus*, *Poa alpina*, *Polygonum viviparum*, *Sibbaldia procumbens*, and *Artemisia norvegica* (in Jasper) occur frequently but with low cover. Total herb-dwarf shrub layer cover is usually 50 to 80%. This v.t. is species rich with a stand often containing 20 to 30 vascular species. Bryoid layer cover varies greatly (10-85%). Lichens are generally more important than bryophytes. Leading species include *Cladonia pyxidata*, *Cetraria ericetorum*, *Cetraria cucullata*, *Peltigera aphthosa*, *Stereocaulon alpinum*, and *Polytrichum juniperinum*.

Table 76 Stands representing the arctic willow-cinquefoil (L7) v.t.

	AM 50 92	IC 90 66	JD 50 64	JD 90 60	LC 91 74	PA 71 22	PA 80 04	PA 80 71	SJ 70 69	SJ 90 81
HERB-DWARF SHRUB LAYER										
Antennaria lanata	06	05	50	25	05	05	.5	03	01	25
Artemisia norvegica	--	15	--	40	05	--	--	--	--	20
Carex spp.	12	--	01	03	.5	.5	01	.5	.5	15
Castilleja occidentalis	03	--	.5	01	03	20	--	10	--	--
Erigeron peregrinus	01	04	03	--	01	05	01	10	.5	02
Luzula wahlenbergii	02	.5	--	--	01	--	--	--	.5	--
Phleum alpinum	.5	--	.5	--	01	--	05	.5	.5	--
Phyllodoce glanduliflora	03	--	10	--	--	03	--	--	--	.5
Poa alpina	.5	--	01	--	02	.5	10	--	--	--
Polygonum viviparum	01	01	--	.5	.5	01	--	08	.5	10
Potentilla diversifolia	01	01	.5	01	05	03	01	01	.5	01
Ranunculus eschscholtzii	02	02	.5	--	--	.5	10	--	--	--
Salix arctica	32	18	15	20	30	30	50	30	15	30
Salix nivalis	--	--	02	--	20	05	--	03	--	02
Sibbaldia procumbens	01	01	.5	--	--	.5	--	.5	.5	06
Trisetum spicatum	--	.5	--	.5	01	01	--	.5	.5	--
Trollius albiflorus	--	.5	--	.5	--	.5	.5	--	--	--
Veronica alpina	.5	--	01	--	.5	--	--	.5	.5	01
BRYOID LAYER										
Brachythecium groenlandicum	--	.5	--	--	--	--	10	.5	--	--
Cetraria ericetorum	--	--	--	.5	01	--	--	03	--	--
Cetraria islandica	--	.5	--	01	--	--	--	--	--	.5
Cladonia spp.	--	--	03	02	04	--	--	.5	.5	.5
Peltigera spp.	--	02	01	--	07	.5	.5	02	02	.5
Polytrichum juniperinum	08	.5	--	--	05	--	--	02	.5	--
Pseudoleskea radicosa	--	--	--	.5	--	--	--	.5	--	--
Tortula norvegica	--	.5	.5	--	--	--	15	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The L7 v.t. is mature successionally.

The L7 v.t. is similar to H16 with many characteristic species in common. However, L7 is dominated by *Salix arctica* and the H16 dominants *Valeriana sitchensis*, *Trollius albiflorus*, and *Anemone occidentalis* are generally absent or with low cover in L7. The H2 v.t. also occurs in snow accumulation areas but meltout appears to occur later in H2. *Carex nigricans* is dominant in H2.

Other Studies: In Banff, Beder (1967, *Salix arctica-Carex*) has described a similar type. In Jasper, similar types have been described by Crack (1977, *Salix arctica*) and Hrapko and La Roi (1978, *Salix arctica-Antennaria lanata*, *Salix arctica-Arctagrostis arundinacea*). In other parts of Alberta, similar types have been described by Mortimer (1978, *Salix arctica-Salix nivalis*), Jacques and Legge (1974, dwarf arctic willow), Trottier (1972, *Salix arctica*), Ogilvie (1976, *Salix nivalis-Salix arctica*), and Kondla (1978, valeriana-anemone-willow). A similar type has been described from Yoho National Park in British Columbia by Kuchar (1978, variegated horsetail/arctic willow/moss meadow).

H1: *Dryas octopetala-Salix nivalis-Silene acaulis*

(mountain avens-snow willow-moss campion)

Environment: The H1 v.t. occurs on mesic to

subxeric, Alpine sites (2300-2550 m B, 2150-2400 m J) on various slopes and most frequently on southerly and westerly aspects. The soils are well drained Orthic Regosols, Orthic Humic Regosols, and Orthic Melanic, Orthic Sombric and Orthic Eutric Brunisols. Turbic and lithic soil phases are common. The landforms are predominantly morainal and colluvial. Solifluction is common.

Vegetation: The H1 tundra (Plate 67) has total herb-dwarf shrub cover of 20 to 50% with *Dryas octopetala* var. *hookeriana* (20-50%), *Salix nivalis* (1-10%), and *Silene acaulis* (1-3%) dominant (Table 77). In some Front Range sites in eastern and northern Jasper, *Dryas integrifolia* replaces *Dryas octopetala*. Other common species are *Oxytropis podocarpa* (<1-3%) and *Polygonum viviparum* (1-2%). Species with low cover but high frequency include *Selaginella densa*, *Potentilla diversifolia*, *Poa alpina*, *Salix arctica*, *Carex nardina*, *Castilleja occidentalis*, *Saxifraga oppositifolia*, *Trisetum spicatum*, and *Potentilla nivea*. Bryoid cover is generally <20% with the lichens *Cetraria nivalis*, *Cetraria cucullata*, *Cetraria ericetorum*, *Cetraria tilesii*, and *Thamnolia subuliformis* most common. H1 occupies wind-swept sites with low winter snow cover and often forms a pattern in the landscape with L5, L4, L7, and H2 occupying progressively deeper snow lie areas.

Table 77 Stands representing the mountain avens -snow willow-moss campion (H1) v.t.

	AN 70 37	1C 80 46	1C 80 66	JC 80 33	JD 70 09	JE 81 62	JH 80 78	PA 70 66	PA 80 47	SJ 80 31
HERB-DWARF SHRUB LAYER										
Anemone parviflora	.5	--	01	--	.5	--	--	01	--	01
Astragalus alpinus	02	--	01	05	.5	--	--	.5	02	--
Carex nardina	--	12	02	--	01	--	--	--	--	--
Carex scirpoidea	--	02	01	--	--	02	--	01	--	--
Castilleja occidentalis	01	.5	.5	.5	.5	--	--	01	--	--
Dryas octopetala	40	50	50	40	40	30	40	40	70	30
Luzula spicata	--	.5	--	.5	--	--	.5	--	01	.5
Oxytropis podocarpa	--	--	04	--	--	.5	03	--	--	02
Polygonum viviparum	--	--	01	05	.5	.5	.5	--	02	08
Potentilla diversifolia	--	.5	.5	02	.5	.5	.5	02	01	02
Salix nivalis	06	10	02	02	20	08	03	10	05	15
Silene acaulis	03	01	02	01	01	.5	.5	.5	02	01
Solidago multiradiata	--	--	--	03	.5	.5	01	.5	.5	--
Selaginella densa	--	02	--	--	--	.5	--	01	--	01
BRYOID LAYER										
Cetraria cucullata	--	--	.5	.5	--	.5	.5	--	--	01
Cetraria ericetorum	--	--	01	.5	--	.5	.5	--	.5	--
Cetraria islandica	02	--	--	.5	--	.5	01	--	01	04
Cetraria nivalis	--	--	01	--	--	.5	--	--	02	02
Cetraria tilesii	--	--	.5	--	--	.5	.5	--	--	.5
Cladonia spp.	--	--	--	.5	01	.5	--	--	.5	.5
Hypnum revolutum	--	--	.5	--	--	.5	.5	--	01	--
Thamnolia subuliformis	--	--	.5	--	--	.5	.5	--	.5	.5
Tortula ruralis	--	--	--	.5	--	.5	15	--	02	01

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The H1 v.t. is successionally mature.

The H1 v.t. is characterized by the dominance of *Dryas octopetala* var. *hookeriana*. In the intricate, fine-scaled patterning of Alpine v.t.s, intergrades with L4 and L5 are common. The O19 v.t. differs by having usually >10% tree cover. The H4 v.t. has much greater amounts of *Kobresia myosuroides* and *Arctostaphylos uva-ursi* than H1.

Other Studies: Similar types were described for Alberta by Mortimer (1978) in the northern Front Ranges (*Dryas integrifolia-Oxytropis podocarpa*), Jeffrey et al. (1968) in the upper Oldman River drainage (alpine tundra), Ogilvie (1976, *Dryas hookeriana*), and See and Bliss (1980) in northern Front Ranges (*Dryas integrifolia-Oxytropis podocarpa-Salix nivalis*). In the Kananaskis area of Alberta, comparable types were described by Kirby and Ogilvie (1969, *Dryas*), Jacques and Legge (1974, *Dryas octopetala*), Kondla (1978, mountain avens) and Trottier (1972, *Dryas octopetala*). In Jasper, similar types were described by Hettinger (1975, *Dryas octopetala-Oxytropis campestris*), Hrapko and La Roi (1978, *Dryas octopetala-Oxytropis podocarpa*, *Dryas octopetala-Festuca brachyphylla*, *Dryas octopetala-Salix nivalis*), La Roi (1975, *Dryas octopetala/Salix nivalis/Polytrichum piliferum/Rhizocarpon geographicum*, *Dryas octopetala/Salix nivalis/Rhacomitrium lanuginosum/Rhizocarpon geographicum*), Kuchar (1975, *Dryas octopetala*/lichen, *Dryas octopetala/Polytrichum piliferum*), and Crack (1977, *Dryas octopetala*). In Banff, similar vegetation was recognized by Broad (1973, *Dryas octopetala-Empetrum nigrum*), Trottier and Scotter (1973, *Dryas octopetala*, *Salix nivalis*), Beder (1967, *Dryas hookeriana-Oxytropis podocarpa-Cetraria cucullata-Cetraria nivalis*), and Knapik et al. (1973, *Dryas hookeriana*, *Dryas hookeriana-Carex scirpoidea*). In Waterton Lakes National Park, the *Dryas* tundra described by Kuchar (1973) is analogous. In northeastern British Columbia, Raup (1934) described similar vegetation in the Mt. Selwyn area and Kuchar (1978) described white dryad tundra in Yoho National Park. Similar Alpine types extend south to Montana as described by Bamberg and Major (1968), Choate and Habeck (1967) on fellfields in Glacier National Park, Montana, and Johnson and Billings (1962, *Dryas octopetala*) in southern Montana.

H2: *Carex nigricans-Antennaria lanata*

(black alpine sedge-everlasting)

Environment: The H2 v.t. occurs on mesic to subhygric, predominantly Alpine (2050-2400 m J; 2180-2500 m B), gentle to steep sites on various aspects. Soils are predominantly moderately well drained Orthic Dystric and Orthic Sombric Brunisols, Orthic Humo-Ferric Podzols, and Regosols developed on morainal and residual landforms. Fluvial veneers are common.

Vegetation: Total cover of the herb-dwarf shrub layer is high (60-100%) (Plate 68) in large part due to *Carex nigricans* (10-90%) which usually forms a dense turf (Table 78).

Table 78 Stands representing the black alpine sedge-everlasting (H2) v.t.

	AW	IC	JC	JC	KS	KS	KS	KS	PA	SJ
	50	70	60	61	50	51	51	60	90	70
	95	66	57	17	55	18	15	77	75	60
HERB-DWARF SHRUB LAYER										
Anemone occidentalis	08	--	--	--	10	25	--	--	--	--
Antennaria lanata	40	.5	03	08	20	25	--	08	15	.5
Arnica mollis	02	--	--	--	--	.5	--	--	--	--
Carex nigricans	35	60	75	60	35	20	98	10	40	31
Cassiope mertensiana	--	--	01	.5	--	--	--	--	--	--
Deschampsia atropurpurea	--	--	--	15	--	.5	--	--	--	09
Erigeron peregrinus	--	--	.5	--	--	--	--	12	--	--
Juncus drummondii	.5	01	.5	--	03	02	--	--	05	.5
Luetkea pectinata	--	.5	--	--	--	--	--	--	--	07
Luzula wahlenbergii	03	.5	.5	05	03	.5	--	02	05	.5
Phleum alpinum	.5	--	--	03	--	.5	.5	--	--	--
Phyllodoce glanduliflora	.5	--	04	.5	10	03	--	.5	--	--
Poa alpina	01	.5	--	--	--	--	--	--	--	--
Poa epilis	.5	--	--	.5	--	02	--	20	--	--
Potentilla diversifolia	01	--	--	--	--	.5	--	01	--	--
Ranunculus eschscholtzii	03	05	--	--	08	03	01	01	--	--
Salix arctica	02	10	01	.5	--	--	--	06	--	--
Sibbaldia procumbens	02	01	04	01	03	01	.5	02	--	--
Vaccinium scoparium	02	--	--	.5	--	--	--	--	--	--
Valeriana sitchensis	02	--	--	--	05	05	--	--	--	--
Veronica alpina	01	.5	--	.5	--	01	--	12	--	--
BRYOID LAYER										
Barbilophozia spp.	--	--	03	02	--	--	--	--	--	--
Brachythecium spp.	01	.5	--	--	--	--	--	--	--	--
Cetraria islandica	--	--	--	--	--	--	05	--	--	.5
Cladonia carneola	--	.5	.5	--	--	--	--	--	.5	.5
Cladonia ecmocyna	--	--	--	--	--	05	--	10	--	--
Cladonia spp.	--	--	--	.5	--	--	--	--	.5	.5
Dicranum spp.	--	.5	.5	--	--	--	--	--	02	.5
Ditrichum flexicaule	--	02	--	--	--	--	--	--	--	--
Grimmia apocarpa	--	02	--	--	--	--	--	--	.5	--
Lepraria neglecta	--	--	--	--	--	--	--	--	08	--
Lepraria spp.	--	--	.5	--	--	.5	--	--	.5	--
Peltigera aphthosa	--	.5	--	01	--	--	--	--	.5	--
Pogonatum alpinum	--	--	03	--	--	20	02	20	--	--
Polytrichum juniperinum	--	--	--	03	20	--	--	--	--	--
Polytrichum piliferum	--	--	03	--	--	--	--	--	02	--
Polytrichum spp.	18	--	--	--	--	--	--	--	--	--
Pseudoleskea radicosa	--	--	--	--	--	.5	--	05	--	.5
Solorina crocea	--	--	--	--	--	--	--	--	02	--
Stereocaulon alpinum	--	--	--	--	--	--	--	05	.5	--
Stereocaulon tomentosum	02	--	--	--	--	--	--	--	--	--
Tortula norvegica	--	.5	--	--	--	--	--	02	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Other characteristic herbs are *Antennaria lanata* (5-35%), *Luzula wahlenbergii* (<5%), *Sibbaldia procumbens* (<5%), *Veronica alpina* (<3%), and *Juncus drummondii* (<5%). On moister sites with later snow lie, *Ranunculus eschscholtzii* (<5%) is often present. *Poa alpina* (<10%) contributes significantly to total cover on some sites as do the dwarf shrubs *Salix arctica* (<12%) and *Phyllodoce glanduliflora* (<10%). The bryoid layer has low cover (<30%) and includes as characteristic species, *Pogonatum alpinum* (2-20%), *Tortula norvegica* (<2%), and *Cladonia ecmocyna* (<5%).

The H2 v.t. is successionally mature.

The H2 v.t. meadows are usually small and occur in areas of late snow lie and melt water runoff within larger areas of vegetation types such as L4, L5, and H1. The H2 v.t. often forms a pattern in the landscape with L7, L4, L5, and H1 occupying progressively shallower snow lie areas. The dominance of *Carex nigricans* readily separates this type from other v.t.s.

Other Studies: The H2 v.t. is a widespread v.t. and has been described by many workers. In Banff, Trottier and Scotter (1973, *Carex nigricans* types), Broad (1973, *Carex nigricans*), Beder (1967, *Carex nigricans*), and Knapik et al. (1973, *Carex nigricans*) have described similar types. Similar types have been described in Jasper by Kuchar (1975, *Carex nigricans*), Hrapko and La Roi (1978, *Carex nigricans-Luzula wahlenbergii*), and Crack (1977, *Carex nigricans*). Elsewhere in Alberta, similar types have been described by Ogilvie (1976, Kirby and Ogilvie 1969, *Carex nigricans*), Jacques and Legge (1974, black sedge), Trottier (1972, *Carex nigricans*), and Kondla (1978, alpine sedge-buttercup). In British Columbia, similar types have been described by Knapik and Landals (1974, *Carex nigricans*) in Mt. Revelstoke National Park and by Kuchar (1978, black alpine sedge types) in Yoho National Park.

H3: *Carex scirpoidea-Saxifraga aizoides*

(sedge-saxifrage)

Environment: The H3 v.t. occurs on hygric Montane to Lower Subalpine sites (1230-1970 m) on level fluvial landforms along river and lake shores. The soils are imperfectly to poorly drained Rego Gleysols. The sites are occasionally inundated and generally have high water tables due to adjacent water bodies.

Table 79 Stands representing the sedge-saxifrage (H3) v.t.

	IC	JC	JD	JD	JN	KS	SJ
	70	80	70	80	81	51	91
	39	44	79	32	17	03	22
SHRUB LAYER							
Betula glandulosa	--	--	05	.5	--	--	03
Picea glauca	02	--	05	--	.5	--	--
Potentilla fruticosa	03	--	02	.5	.5	--	03
Salix spp.	.5	--	.5	15	04	--	07
HERB-DWARF SHRUB LAYER							
Anemone parviflora	.5	02	05	.5	--	03	01
Arctostaphylos rubra	--	01	.5	.5	.5	--	--
Carex scirpoidea	04	--	25	01	09	05	--
Castilleja occidentalis	.5	01	--	.5	--	.5	10
Dryas integrifolia	05	--	.5	25	01	--	--
Polygonum viviparum	.5	02	--	.5	--	15	--
Saxifraga aizoides	.5	05	--	02	--	15	.5
Tofieldia pusilla	.5	08	--	.5	.5	--	02
BRYOID LAYER							
Catoscopium nigritum	--	--	05	01	--	--	--
Drepanocladus revolvens	--	--	--	--	10	--	10
Bryum spp.	--	--	--	--	05	--	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: The H3 v.t. is dominated by herbs (Plate 69) including *Carex scirpoidea* (1-5%), *Saxifraga aizoides* (1-5%), *Anemone parviflora* (1-3%), and *Tofieldia pusilla* (<3%) (Table 79). Common species with low cover include *Polygonum viviparum*, *Equisetum variegatum*, *Castilleja occidentalis*, *Dryas integrifolia*, *Arctostaphylos rubra*, and *Pinguicula vulgaris*. Scattered shrubs of *Potentilla fruticosa* and *Salix* spp. also occur

often. Total herb-dwarf shrub cover is usually 50 to 75%. Bryoid cover is generally <15% with unvegetated soil providing 30 to 50% cover.

The successional status of H3 is problematic. Periodic flooding and deposition appear to maintain some stands in this state for long periods. Other stands, perhaps less frequently disturbed, appear to increase in shrub cover and become S7. Thus, H3 can be characterized as early to intermediate successionally, with the successional development of some stands retarded by periodic disturbance.

The H3 v.t. can be distinguished from S7 by having sparse shrub cover and different herb-dwarf shrub layer dominants.

Other Studies: Descriptions of similar types by other authors were not found.

H4: *Dryas octopetala-Kobresia myosuroides-Arctostaphylos uva-ursi*

(mountain avens-kobresia-bearberry)

Environment: The H4 v.t. occurs on subxeric to mesic Upper Subalpine to Alpine (1750-2400 m J, 2000-2580 m B) sites of moderate to steep slope and southerly aspect, mostly in the Front Ranges of Banff and Jasper. The soils are generally well drained Orthic Melanic Brunisols, Orthic Eutric Brunisols, and Orthic Humic Regosols developed on morainal and colluvial landforms.

Vegetation: Tree and shrub cover is usually absent (Plate 70) although scattered krummholz *Abies lasiocarpa* and *Picea engelmannii* may be present. The herb-dwarf shrub layer has abundant cover (50-100%, Table 80) dominated by *Dryas octopetala* (10-35%), although *Dryas integrifolia* may substitute in some Front Range stands. Other plants usually present are *Kobresia myosuroides* (15-40%), *Arctostaphylos uva-ursi* (5-30%), *Polygonum viviparum* (<5%), *Androsace chamaejasme* (<3%), *Oxytropis podocarpa* (<15%), and *Silene acaulis* (<2%). *Elymus innovatus* is usually absent but may have cover up to 25%. The bryoid layer is dominated by lichens especially *Cetraria* spp., with *Cetraria nivalis* (<10%) and *Cetraria cucullata* (<10%) being dominant. Moss cover is sparse (<5%) with total bryoid cover being 0 to 30%.

Successionally H4 is mature.

The H4 v.t. is distinguished from H1 by usually having abundant *Kobresia myosuroides* and *Arctostaphylos uva-ursi* and by the generally steep southerly aspects. The H4 v.t. is distinguished from H5 and H14 by the usually abundant *Kobresia* and *Arctostaphylos* and generally sparse *Elymus innovatus*. Intergrades with H14 occur.

Table 80 Stands representing the mountain avens-kobresia-bearberry (H4) v.t.

	AW 70 94	IC 80 05	IC 80 48	JC 60 68	JC 70 25	JD 50 99	JE 81 20	PA 80 16	PA 80 48	PA 81 12
HERB-DWARF SHRUB LAYER										
Androsace chamaejasme	.5	.5	.5	02	02	--	.5	.5	.5	.5
Arctostaphylos rubra	--	--	--	02	--	--	--	--	--	--
Arctostaphylos uva-ursi	--	.5	--	--	15	--	05	15	40	.5
Arnica alpina	.5	--	.5	--	--	--	.5	--	--	--
Astragalus alpinus	03	--	--	--	--	.5	.5	--	--	--
Bromus pumpellianus	02	--	.5	--	--	01	.5	--	.5	--
Carex nardina	05	--	--	--	--	--	--	--	--	--
Carex nigricans	--	--	--	15	--	--	--	--	--	--
Carex scirpoidea	--	--	--	--	25	--	--	--	--	.5
Cassiope tetragona	--	--	--	01	--	--	--	--	--	--
Dryas octopetala	19	03	--	30	--	40	20	15	10	25
Dryas integrifolia	--	--	04	--	35	--	--	--	--	--
Elymus innovatus	--	--	.5	--	--	--	--	--	08	--
Gentiana prostrata	.5	--	.5	--	--	--	--	.5	--	--
Hedysarum alpinum	--	--	08	--	.5	--	--	.5	--	--
Hedysarum mackenzii	--	--	08	10	04	--	--	01	--	05
Hedysarum sulphurescens	--	--	--	--	--	--	03	--	03	--
Juniperus communis	--	--	--	--	--	--	--	--	01	--
Kobresia myosuroides	15	35	40	20	02	45	12	20	02	20
Oxytropis podocarpa	.5	01	.5	01	--	03	--	.5	.5	03
Poa alpina	--	01	--	--	--	01	--	--	05	.5
Polygonum viviparum	.5	01	04	03	.5	.5	.5	02	.5	02
Potentilla diversifolia	.5	--	--	--	--	.5	.5	--	--	--
Potentilla fruticosa	--	--	--	--	--	--	.5	--	02	.5
Salix glauca	--	--	--	--	--	--	--	--	05	--
Salix nivalis	--	01	--	03	--	03	.5	01	--	--
Saxifraga oppositifolia	.5	--	--	.5	--	.5	--	.5	--	--
Silene acaulis	.5	.5	01	02	--	--	--	02	--	.5
Solidago multiradiata	05	--	--	--	--	.5	.5	.5	.5	.5
Trisetum spicatum	01	.5	--	.5	--	.5	--	--	--	--
Selaginella densa	04	--	--	--	--	--	.5	.5	--	--
BRYOID LAYER										
Bryum spp.	--	--	--	--	--	--	--	--	.5	.5
Cetraria cucullata	--	01	01	--	.5	02	01	05	--	.5
Cetraria ericetorum	04	02	.5	--	.5	--	01	02	--	05
Cetraria islandica	--	--	--	--	--	--	.5	03	--	--
Cetraria nivalis	--	01	.5	--	--	01	03	10	.5	10
Cetraria tilesii	04	.5	--	--	--	--	--	02	--	.5
Cladonia pyxidata	--	--	.5	--	--	--	.5	.5	--	--
Cladonia spp.	--	--	.5	--	--	--	--	02	--	.5
Coelocaulon aculeatum	--	01	--	--	--	--	--	.5	--	.5
Ditrichum flexicaule	--	.5	.5	--	--	.5	--	--	--	--
Encalypta rhaptocarpa	--	.5	--	--	--	--	.5	--	--	.5
Hypnum revolutum	--	--	--	--	--	.5	01	--	--	--
Myurella julacea	--	.5	.5	--	--	.5	--	--	--	.5
Physconia muscigena	--	.5	.5	--	--	.5	--	--	--	--
Rhytidium rugosum	--	.5	02	--	.5	--	--	.5	--	--
Thamnolia subuliformis	--	.5	.5	--	--	05	.5	01	--	.5
Tortella fragilis	--	--	--	--	--	--	--	.5	.5	.5
Tortula ruralis	.5	05	--	--	--	.5	--	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Other Studies: In Banff, Knapik et al. (1973, *Kobresia myosuroides*) have described a similar type. Similar types have been described in Jasper by Kuchar (1975, *Kobresia bellardii*), Crack (1977, *Kobresia myosuroides, Arctostaphylos uva-ursi*), and Hrapko and La Roi (1978, *Dryas octopetala-Kobresia bellardii*). In other parts of Alberta, Ogilvie (1976, Kirby and Ogilvie 1969, *Kobresia myosuroides*), Jacques and Legge (1974, kobresia), Trottier (1972, *Kobresia myosuroides*), and Johnson (1975, *Dryas integrifolia-Selaginella densa-Kobresia myosuroides, Arctostaphylos uva-ursi-Dryas integrifolia, Dryas integrifolia-Kobresia-Potentilla fruticosa*) have described similar types. Bamberg and Major (1968) have described similar stands from the Big Snowy Mountains of central Montana and in Glacier National Park, Montana.

H5: *Elymus innovatus-Fragaria virginiana-Epilobium angustifolium*

(hairy wild rye-wild strawberry-fireweed)

Environment: The H5 grasslands occur on generally mesic usually Upper Subalpine (1720-2000 m J, - 2270 m B) steeply sloping sites of southerly aspect. Soils are predominantly well drained Orthic Melanic Brunisols and Humic Regosols on colluvial landforms. Sites of H5 are subject to frequent snow avalanching.

Table 81 A stand representing the hairy wild rye-wild strawberry-fireweed (H5) v.t.

	AW 51 38	AW 60 07	CE 50 27	IC 50 64	IC 60 11	IC 70 30	JC 70 39	PA 71 58	PA 80 11	PA 90 27
SHRUB LAYER										
Amelanchier alnifolia	--	.5	--	--	--	.5	--	--	--	--
Juniperus communis	--	--	.5	--	.5	.5	--	--	--	--
Pinus albicaulis	--	--	02	--	--	--	--	--	--	--
Populus tremuloides	--	02	--	--	--	--	--	--	--	--
Potentilla fruticosa	--	--	01	02	--	.5	--	--	--	--
Rosa acicularis	--	01	--	.5	04	03	01	--	--	--
Salix glauca	--	--	--	--	--	--	01	--	--	--
Shepherdia canadensis	--	--	03	--	.5	--	--	--	--	--
Symphoricarpos albus	--	08	--	--	--	--	--	--	--	--
HERB-DWARF SHRUB LAYER										
Achillea millefolium	05	02	.5	01	.5	01	02	05	--	.5
Agropyron latiglume	--	--	--	--	--	--	--	08	--	--
Agrostis variabilis	--	--	--	10	--	01	--	--	--	--
Anemone multifida	.5	--	--	.5	.5	.5	02	--	--	--
Antennaria nitida	02	--	--	--	--	.5	--	.5	--	--
Aquilegia flavescens	--	--	03	--	02	--	--	--	--	--
Arctostaphylos uva-ursi	--	02	--	--	--	03	--	--	--	.5
Arnica cordifolia	--	.5	--	--	--	--	--	--	--	02
Aster ciliolatus	--	--	01	--	01	--	--	10	--	--
Aster conspicuus	--	25	--	--	01	--	--	--	--	--
Astragalus alpinus	01	--	--	--	01	--	06	01	--	.5
Calamagrostis purpurascens	--	--	--	--	--	01	02	--	--	--
Campanula rotundifolia	01	05	--	01	--	--	--	--	--	--
Carex praticola	--	--	--	--	--	--	--	--	10	--
Carex scirpoides	--	--	--	10	.5	03	--	.5	--	--
Carex vaginata	08	--	--	--	--	--	--	--	--	--
Castilleja occidentalis	--	.5	--	.5	--	--	04	--	--	--
Castilleja rhexifolia	--	--	--	--	05	--	--	--	--	--
Cirsium hookerianum	--	.5	--	.5	--	.5	01	10	--	--
Clavinia lanceolata	--	--	--	--	--	--	--	--	--	10
Delphinium glaucum	03	--	--	--	--	--	--	--	--	15
Deschampsia atropurpurea	--	01	--	--	--	--	--	--	02	--
Elymus innovatus	--	38	15	60	55	45	35	20	40	50
Epilobium angustifolium	10	01	--	01	.5	--	05	05	--	05
Erigeron peregrinus	06	--	--	--	--	--	--	--	--	05
Fragaria virginiana	14	01	05	01	01	--	04	05	.5	10
Galium boreale	--	--	--	01	.5	.5	--	--	--	.5
Gentiana amarella	--	--	--	--	--	--	--	02	--	--
Geranium richardsonii	--	--	--	--	05	--	--	--	--	--
Hackelia jessicae	.5	01	--	--	--	--	--	--	--	--
Hedysarum alpinum	--	03	--	01	.5	--	--	02	--	--
Hedysarum sulphurescens	01	--	--	--	--	15	--	--	--	--
Heracleum lanatum	03	--	--	--	.5	--	--	--	--	.5
Koeleria cristata	--	--	--	01	--	--	05	--	--	--
Mertensia paniculata	--	--	--	--	--	--	--	--	10	--
Myosotis alpestris	.5	02	--	.5	--	--	10	--	10	03
Oxytropis splendens	--	--	--	--	--	--	01	01	--	.5
Penstemon confertus	.5	02	--	--	--	--	--	--	--	--
Phleum alpinum	06	--	--	--	.5	--	--	10	--	.5
Poa alpina	--	--	--	--	--	--	--	--	03	--
Poa spp.	02	--	--	--	--	01	--	02	.5	.5
Potentilla diversifolia	.5	--	--	.5	--	01	--	.5	20	.5
Rumex alpestris	--	--	--	--	--	--	--	--	.5	02
Senecio indecorus	05	02	--	--	--	--	--	--	--	--
Smilacina stellata	--	--	--	.5	04	.5	--	--	--	--
Solidago decumbens	--	--	--	--	--	01	--	.5	--	--
Solidago multiradiata	01	--	--	--	--	--	02	--	--	--
Stellaria spp.	--	--	--	--	.5	02	--	--	--	--
Thalictrum occidentale	01	--	03	--	.5	--	01	--	--	10
Trisetum spicatum	03	--	--	--	.5	--	--	05	--	--
Valeriana sitchensis	03	--	--	--	--	--	--	--	--	--
Zygadenus elegans	--	--	01	.5	03	05	04	--	--	05
BRYOID LAYER										
Thuidium abietinum	--	--	--	--	05	--	--	--	--	05 .5
Tortula ruralis	--	--	--	--	.5	--	--	07	.5	.5 .5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: Tree cover is absent (Plate 71) or limited to scattered individuals particularly towards the edges of the avalanche paths. Shrub cover is low (<10%), primarily *Salix* spp. and *Rosa acicularis* (<5%) (Table 81). The herb-dwarf shrub layer is dense (55-100%) and is dominated by *Elymus innovatus* (15-55%), *Fragaria virginiana* (1-10%), and *Epilobium angustifolium* (<10%). Other characteristic species are *Achillea millefolium* (<5%), *Myosotis alpestris* (<10%) *Potentilla diversifolia* (<1%), and *Zygadenus elegans* (<8%). The bryoid layer has sparse cover (<5%).

Successionally, H5 is mature, the herbaceous physiognomy being maintained by frequent avalanches.

The H5 v.t. is distinguished from other grassland types (H6,H7,H13) by the dominance of *Elymus innovatus* and a much higher elevation, and from H14 by being more mesic and lacking or having in low abundance characteristic H14 species such as *Koeleria cristata*, *Hedysarum* spp. and *Bromus pumpellianus*. H5 is distinguished from H4 by the absence of *Dryas octopetala* and *Kobresia myosuroides* and the presence of moister site conditions with lower elevations. Moist stands with abundant *Erigeron peregrinus* and *Valeriana sitchensis* may be transitional to H16. Stands with abundant *Salix* or *Abies lasiocarpa* may be transitional to S2.

Other Studies: In Alberta, similar types have been described only from the Front Ranges of the Rocky Mountains. Kirby and Ogilvie (1969) described a similar "seepage avalanche meadow type" and similar vegetation was described by Mortimer (1978, *Elymus innovatus-Mertensia paniculata*), Jacques and Legge (1974) in the Kananaskis area (*Elymus innovatus*), Kondla (1978, herb avalanche track) in the Kananaskis area, and Trottier (1972) in the Highwood Pass area (*Thalictrum occidentale*).

H6: *Koeleria cristata-Artemisia frigida-Linum lewisii*

(junegrass-pasture sage-wild blue flax)

Environment: The H6 grasslands occur on subxeric to xeric Montane (1250-1620 m B, 1000-1140 m J), level to moderately sloping sites of level to southerly aspect. Soils are rapidly to well drained Orthic Regosols, Humic Regosols, and Orthic Eutric Brunisols developed on fluvial, eolian, and glaciofluvial landforms.

Vegetation: *Koeleria cristata* (15-30%) is the dominant plant; its cover can vary widely between years depending upon summer precipitation (Table 82). Other characteristic species are *Artemisia frigida* (1-20%), *Linum lewisii* (1-10%), *Antennaria nitida* (1-10%), *Senecio cymbalarioides* (1-5%), *Galium boreale* (<5%), and *Gaillardia aristata* (<5%).

Herb-dwarf shrub layer cover is 25 to 90% (Plate 72). Cover of the bryoid layer is <3% with *Tortula ruralis* the most frequently occurring moss.

Table 82 Stands representing the junegrass-pasture sage-wild blue flax (H6) v.t.

	1C 50 10	1C 51 41	1C 70 56	JC 70 07	JE 90 19	JM 70 10	JM 70 11	KS 51 64	SC 70 25	SJ 90 01
HERB-DWARF SHRUB LAYER										
Achillea millefolium	.5	--	--	--	--	--	02	--	--	--
Agropyron dasystachyum	01	--	--	--	--	--	--	--	25	12
Agropyron inerme	--	--	.5	--	--	05	--	--	--	--
Agropyron subsecundum	--	--	--	--	--	--	--	20	--	--
Anemone multifida	.5	.5	--	--	--	--	01	.5	--	--
Antennaria nitida	07	10	--	--	--	--	10	05	--	.5
Artemisia campestris	--	--	--	--	--	--	03	--	--	--
Artemisia frigida	--	.5	05	08	25	05	03	05	06	12
Artemisia michauxiana	--	--	--	--	--	05	--	--	01	.5
Aster alpinus	.5	--	--	--	--	--	--	03	--	--
Astragalus decumbens	--	--	--	--	--	--	03	01	--	.5
Astragalus striatus	--	--	--	--	--	--	02	02	--	--
Astragalus tenellus	--	--	--	--	--	05	--	--	--	--
Bromus spp.	--	--	--	--	05	--	--	--	--	.5
Calamagrostis purpurascens	--	--	.5	01	--	07	15	--	15	--
Campanula rotundifolia	.5	.5	--	--	--	--	--	--	.5	--
Carex filifolia	--	--	--	--	--	01	--	--	--	.5
Carex spp.	--	--	--	--	--	--	05	--	--	--
Commandra pallida	--	--	.5	--	--	01	01	01	--	--
Erigeron caespitosus	--	--	03	--	--	--	.5	02	--	--
Erigeron grandiflorus	--	--	--	--	--	--	--	--	03	--
Festuca scabrella	--	--	--	--	--	--	--	--	03	--
Gaillardia aristata	.5	.5	--	--	--	05	--	01	--	--
Gallium boreale	.5	--	--	--	--	--	03	.5	.5	05
Koeleria cristata	10	20	30	40	35	15	15	30	25	20
Linum lewisii	.5	--	07	02	--	02	02	08	20	05
Lithospermum incisum	--	--	--	--	--	--	02	--	--	--
Oxytropis sericea	--	04	--	--	--	--	--	--	--	--
Oxytropis splendens	--	--	--	--	--	--	--	25	--	--
Senecio cymbalarioides	01	.5	--	05	.5	--	--	--	.5	05
Senecio pauciflorus	--	--	04	--	--	01	.5	--	--	--
Solidago decumbens	.5	--	--	--	--	--	.5	.5	--	--
Taraxacum officinale	.5	--	--	--	--	--	02	.5	02	--
BRYOID LAYER										
Cladonia spp.	--	--	--	--	--	--	--	30	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

The H6 v.t. is successionally mature, but it appears that in areas such as near Henry House in Jasper, that the lodgepole pine/juniper/bearberry v.t. (C3) may be encroaching upon the grasslands.

The H6 v.t. is distinguished from H13 and H7 by the dominance of *Koeleria cristata* rather than by *Stipa richardsonii* and *Agropyron dasystachyum* respectively. The dominance in H14 of *Elymus innovatus* and Subalpine elevations distinguish it from H6.

Other Studies: Similar types have been described from Banff and Jasper by Stringer (1973, *Koeleria-Calamagrostis montanensis*, *Koeleria-Geum triflorum*) and from Jasper by La Roi (1975, *Koeleria cristata/Antennaria nitida/Bryum caespiticium*).

H7: ***Agropyron dasystachyum-Artemisia frigida***

(wheatgrass-pasture sage)

Environment: The H7 grasslands occur on xeric Montane (1540-1640 m B, 1040-1300 m J) generally steeply sloping sites of southerly aspect. Soils are rapidly to well drained Orthic Eutric Brunisols and Orthic Regosols developed on colluvial, glacial, and fluvial landforms.

Vegetation: Herb-dwarf shrub cover is usually 20 to 50% (Plate 73) and dominated by *Agropyron dasystachyum* (5-50%) with lesser amounts of *Artemisia frigida* (1-10%), *Koeleria cristata* (2-10%), and *Achillea millefolium* (<5%) (Table 83). Moss and lichen cover is negligible in most stands with total cover generally <1% while bare mineral soil is often up to 50% of the ground surface.

Table 83 Stands representing the wheatgrass-pasture sage (H7) v.t.

	AW 70 13	1C 50 16	1C 50 18	1C 90 09	JD 50 14
SHRUB LAYER					
Juniperus communis	03	--	--	--	--
Populus tremuloides	04	--	--	--	--
HERB-DWARF SHRUB LAYER					
Achillea millefolium	01	.5	.5	02	10
Agropyron dasystachyum	--	03	10	15	50
Androsace septentrionalis	.5	--	--	.5	.5
Antennaria nitida	--	--	--	02	--
Antennaria rosea	--	--	--	--	01
Arctostaphylos uva-ursi	03	--	--	--	--
Artemisia frigida	11	05	02	01	--
Carex eleocharis	--	30	--	--	--
Cerastium arvense	--	--	--	03	--
Erigeron compositus	--	--	--	08	--
Fragaria virginiana	--	--	--	04	--
Gaillardia aristata	02	--	--	--	--
Koeleria cristata	04	35	--	03	02
Oxytropis splendens	--	--	--	03	.5
Penstemon confertus	--	--	--	--	05
Poa glauca	--	10	--	--	--
Rosa acicularis	03	--	.5	--	--
Vicia americana	.5	--	--	.5	.5
BRYOID LAYER					
Cetraria ericetorum	--	10	--	--	--
Parmelia chlorochroa	--	10	--	--	--
Physconia muscigena	--	10	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

The H7 v.t. is successionally mature.

The H7 v.t. is distinguished from all other grasslands by the dominance of *Agropyron dasystachyum*, but stands with abundant *Koeleria cristata* may be transitional to H6. The absence of *Stipa richardsonii* and the presence of usually steep slopes in H7 distinguish this v.t. from H13. The dominance in H14 of *Elymus innovatus* and Subalpine elevations distinguish it from H7.

Other Studies: A similar type was described by La Roi (1975, *Agropyron dasystachyum/Artemisia frigida*) for Jasper.

H8: ***Dryas drummondii-Epilobium latifolium***

(yellow dryad-willow herb)

Environment: The H8 v.t. occurs on subxeric to subhygric Montane to Lower Subalpine

(1000-1700 m) sites of usually gentle slopes on various aspects. The soils are usually rapidly, but may be imperfectly, drained Orthic Regosols and Orthic Humic Regosols developed on recent fluvial, glaciofluvial and morainal landforms.

Vegetation: Tree cover is usually limited to scattered *Picea glauca* and *Picea engelmannii* with occasional representatives of other species although trees are often absent (Table 84). Shrub cover is generally low (<15%) but may be greater on moist sites. Usual species are *Shepherdia canadensis* (<10%), *Salix brachycarpa* (<15%), and other *Salix* spp.. The herb-dwarf shrub layer is species poor, dominated by *Dryas drummondii* with 25 to 80% cover (Plate 74). *Epilobium latifolium* (<2%) is the other characteristic species of this type and is usually found in moist depressions and near stream channels. *Arctostaphylos uva-ursi* (<5%) is often present in dry stands. The bryoid layer has low cover (<10%) with common representatives being *Drepanocladus uncinatus* (<3%) and *Tortula norvegica* (<10%).

Table 84 Stands representing the yellow dryad-willowherb (H8) v.t.

	AK 70 41	JC 81 10	JC 80 93	JC 90 40	JC aC 57	PA 7C 92	PA 7C 69	PA 8 03	SJ 70 03	SJ 9 03
TREE LAYER										
Picea engelmannii	--	--	--	08	--	--	--	--	--	--
Picea glauca	--	--	--	--	--	--	--	--	01	--
Populus balsamifera	--	05	--	--	--	--	--	--	01	--
TALL SHRUB LAYER										
Picea engelmannii	--	--	--	08	.5	--	02	15	--	--
Picea glauca	01	03	--	--	--	--	--	--	20	--
SHRUB LAYER										
Alnus tenuifolia	--	10	--	--	--	--	--	--	--	--
Elaeagnus commutata	--	--	--	--	--	--	--	--	05	--
Picea engelmannii	--	--	--	03	02	--	03	05	--	--
Picea glauca	03	--	--	--	--	--	--	--	04	--
Salix brachycarpa	01	--	--	--	20	05	--	--	--	10
Salix farrae	--	--	--	--	--	05	--	--	--	15
Shepherdia canadensis	--	.5	--	14	01	01	.5	--	02	.5
HERB-DWARF SHRUB LAYER										
Antennaria pulcherrima	--	--	--	--	--	05	--	--	--	--
Arctostaphylos rubra	--	--	--	--	--	01	--	--	--	01
Arctostaphylos uva-ursi	--	--	--	--	02	05	.5	--	01	--
Carex concinna	--	--	--	--	.5	--	01	--	--	.5
Castilleja miniata	--	.3	--	--	--	.5	--	--	--	--
Castilleja occidentalis	--	--	--	--	--	.5	--	--	--	07
Dryas drummondii	50	25	45	52	25	25	80	75	20	07
Dryas integrifolia	--	--	--	--	--	10	--	--	--	--
Epilobium latifolium	01	--	--	--	.5	.5	02	--	--	--
Hedysarum alpinum	--	--	--	--	.5	--	--	--	--	07
Oxytropis splendens	--	--	--	--	--	03	--	--	--	05
Tofieldia glutinosa	--	--	--	--	--	03	--	--	--	--
BRYOID LAYER										
Brachythecium groenlandicum	--	--	--	--	.5	.5	--	--	--	01
Catoscopium nigritum	--	--	--	--	--	10	--	--	--	--
Cladonia pyxidata	.5	--	--	.5	--	--	--	--	--	--
Drepanocladus uncinatus	03	--	--	.5	--	--	.5	.5	--	--
Funaria hygrometrica	--	--	--	--	--	--	--	--	--	05
Pohlia drummondii	--	--	--	--	01	--	--	.5	--	--
Tortella inclinata	.5	--	--	.5	--	.5	--	--	--	--
Tortella tortuosa	--	--	--	.5	--	--	--	--	--	01
Tortula norvegica	01	--	--	--	.5	--	--	.5	--	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Successionally H8 is early and appears to be seral to O3.

The H8 v.t. is readily separable from other types by the dominance of *Dryas drummondii* and occurrence on recent landforms. Stands transitional to H3 and S7 occur in moist situations and to O3 on long-stabilized fluvial materials.

Other Studies: Heusser (1956) described a type similar to H8 for Banff and Jasper. Other similar types in British Columbia have been described by Kuchar (1978, yellow dryad) in Yoho National Park and by Raup (1934, *Dryas drummondii*) in northeastern British Columbia. In the Yukon Territory, Douglas (1974, *Dryas drummondii*) in Kluane National Park and Orloci and Stanek (1979, *Dryas drummondii*) have described similar types. Kershaw (1981, *Dryas drummondii*) described a similar type in Nahanni National Park.

H9: *Caltha leptosepala-Trollius albiflorus*

(mountain marigold-globeflower)

Environment: The H9 herb meadows occur on subhygric to hygric Upper Subalpine to Alpine (2330-2400 m B, 1880-2300 m J) gently to moderately sloping sites of northerly to easterly aspect. Soils are poorly drained Gleysols developed on fluvial and morainal landforms. H9 sites are usually depressional, in areas where snow melts late and seepage is received throughout the growing season.

Vegetation: Herb-dwarf shrub cover is high (70-100%, Plate 75) and is dominated by *Caltha leptosepala* (10-25%) and *Trollius albiflorus* (15-40%) with lesser amounts of *Senecio triangularis* (<10%), *Erigeron peregrinus* (<10%), *Carex nigricans* (5-20%), *Antennaria lanata* (<10%), *Salix arctica* (5-10%), *Pedicularis bracteosa* (<5%), *Polygonum viviparum* (<5%), and *Valeriana sitchensis* (<5%) (Table 85). Bryoid cover is 20 to 75% with the common dominants being *Aulacomnium palustre* (10-50%) and *Campylium stellatum* (<10%). *Drepanocladus uncinatus*, *Philontis fontana* and *Tomenthypnum nitens* may be locally abundant or dominant but are often absent.

The H9 v.t. is successionally mature.

The H9 v.t. is distinguished from all other v.t.s by the dominance of *Caltha leptosepala* and wet site conditions. Where water is free-standing for a large part of the growing season, stands may be transitional to H10. Where the site is not as wet as the modal H9, the vegetation may be transitional to H16 or H2. H9 meadows are usually small in extent and generally occur within areas of L4, L5, and H1.

Other Studies: Similar types were described by Kuchar (1975) in Jasper (*Artemisia nor-*

vegica/Salix arctica), Broad (1973) at Bow Summit in Banff (*Trollius albiflorus-Caltha leptosepala*), and Trottier and Scotter (1973) in Banff (*Carex/Caltha leptosepala/Sphagnum*).

Table 85 Stands representing the mountain marigold-globe flower (H9) v.t.

	IC 61 10	IC 91 41	JC 60 59	JC 61 09	KS 60 78	PA 71 68	PA 90 62	SJ 90 76	SJ 90 83	SJ 91 09
HERB-DWARF SHRUB LAYER										
Anemone occidentalis	--	03	--	--	--	--	--	20	--	--
Anemone parviflora	--	--	01	--	--	--	--	--	--	--
Anemone richardsonii	--	--	--	--	--	--	--	--	05	--
Antennaria lanata	15	--	--	02	08	--	01	01	.5	02
Arnica mollis	--	--	--	01	02	--	--	--	--	--
Artemisia norvegica	01	--	05	01	--	--	10	--	10	--
Caltha leptosepala	10	23	15	06	10	03	15	05	23	40
Carex nigricans	10	05	10	01	.5	--	--	--	04	25
Carex spectabilis	--	03	--	--	.5	--	--	--	04	--
Carex sp.	01	--	05	.5	--	--	--	--	--	--
Cassiope mertensiana	--	--	.5	02	--	--	--	10	.5	05
Castilleja occidentalis	.5	.5	--	--	.5	--	.5	--	02	--
Claytonia lanceolata	--	--	--	--	02	--	--	08	--	--
Erigeron peregrinus	08	03	02	15	15	.5	10	10	02	--
Hippuris vulgaris	--	--	--	--	--	--	--	--	--	12
Juncus drummondii	05	--	02	--	.5	--	.5	--	--	--
Juncus mertensianus	--	--	--	--	--	15	--	--	--	--
Luetkea pectinata	04	--	--	03	--	--	--	--	--	09
Parnassia fimbriata	--	--	--	--	--	05	--	--	--	--
Parnassia sp.	--	--	--	--	--	--	--	.5	01	--
Pedicularis bracteosa	.5	--	.5	01	02	--	01	02	02	--
Phyllodoce glanduliflora	--	--	--	01	.5	--	--	--	--	--
Polygonum viviparum	--	05	20	--	02	01	--	.5	05	--
Potentilla diversifolia	--	--	01	--	--	--	.5	02	03	--
Ranunculus eschscholtzii	01	--	.5	--	02	--	--	--	--	.5
Ranunculus occidentalis	--	02	--	--	--	--	.5	--	--	--
Senecio triangularis	15	08	06	02	01	.5	03	--	02	--
Sibbaldia procumbens	--	.5	.5	--	03	--	--	--	--	--
Trollius albiflorus	15	40	15	40	45	10	35	15	34	--
Valeriana sitchensis	01	--	--	10	--	--	--	07	02	--
Veratrum eschscholtzii	--	--	--	--	--	--	--	01	--	01
Veronica alpina	--	.5	.5	--	--	--	.5	--	--	--
Salix arctica	--	.5	15	01	05	05	--	05	06	--
Salix barrattiana	--	--	--	--	--	--	05	--	--	--
Salix nivalis	--	--	01	01	--	.5	--	--	--	--
Vaccinium scoparium	--	--	03	--	--	--	--	--	--	--
BRYOID LAYER										
Aulacomnium palustre	15	45	30	65	.5	--	10	--	10	.5
Barbilophozia hatcheri	--	--	--	05	--	--	--	--	--	.5
Brachythecium sp.	--	--	--	--	--	--	--	10	--	--
Campylium stellatum	--	.5	20	05	--	10	--	--	.5	--
Dicranum scoparium	--	--	--	--	--	--	--	--	--	05
Dicranum sp.	--	--	--	02	--	--	--	--	--	--
Drepanocladus uncinatus	--	.5	--	--	--	--	--	--	.5	.5
Drepanocladus sp.	--	--	10	01	--	--	--	--	--	--
Hylocomium pyrenaicum	--	.5	--	--	--	--	--	--	.5	--
Lophozia floerkii	.5	--	--	--	--	--	--	--	--	02
Philonotis fontana	--	--	--	--	85	25	--	--	--	--
Polytrichum juniperinum	--	--	--	02	--	--	--	--	--	--
Pseudocalliergon radicosa	--	--	--	.5	--	--	--	.5	--	--
Tomenthypnum nitens	--	--	--	--	--	40	--	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

H10: ***Eriophorum angustifolium/Drepanocladus*** **spp.**

(cottongrass/moss)

Environment: The H10 fens occur on hydric Upper Subalpine (1970-2220 m) level to very gently sloping (<5%) sites on various aspects at the Upper Subalpine to Alpine boundary. Soils are poorly to very poorly drained Rego Gleysols and Terric Mesisols developed on fluvial landforms and to a lesser extent on morainal landforms with fluvial veneers. H10 sites are usually depressional areas where snow melts late and seepage is received throughout the growing season.

Vegetation: Cover of the herb-dwarf shrub layer (Plate 76) is moderate to high (20-60%) most of which is attributable to *Eriophorum angustifolium* (Table 86). Toward the edges of this v.t. where free standing water is less abundant, species such as *Caltha leptosepala*, *Carex nigricans*, *Pedicularis groenlandica*, and *Scirpus caespitosus* may occur with varying cover. The often submerged bryoid layer has generally high cover (70-80%) dominated by *Drepanocladus exannulatus* and *Drepanocladus revolvens*. Other mosses with often high cover are *Paludella squarrosa* and *Calliergon sarmentosum*.

Table 86 Stands representing the cottongrass moss (H10) v.t.

	CE 50 45	IC 91	JM 70
SHRUB LAYER			
Betula glandulosa	05	--	--
Salix barclayi	--	05	--
Salix barrattiana	15	--	--
HERB-DWARF SHRUB LAYER			
Carex canescens	--	--	50
Carex limosa	--	--	05
Eriophorum angustifolium	30	18	07
Pedicularis groenlandica	20	--	--
BRYOID LAYER			
Aulacomnium palustre	--	.5	01
Bryum sp.	--	01	--
Calliergon sarmentosum	--	25	--
Drepanocladus exannulatus	--	25	70
Drepanocladus revolvens	10	--	--
Paludella squarrosa	--	30	--
Tomenthypnum nitens	--	01	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

The H10 v.t. is successionally mature.

The H10 v.t. is distinguished from other v.t.s by the dominance of *Eriophorum angustifolium* and site conditions characterized by standing or slowly flowing water during the growing season. Toward the periphery, where conditions are less wet, a gradient from H10 to H9 to H16 may occur as soil drainage improves. The H10 meadows are small in extent and occur in depressions within larger areas of O10, O9, and S8 vegetation.

Other Studies: In Banff, similar types have been described by Trottier and Scotter (1973, *Eriophorum* spp.-*Carex aquatilis*) and Knapik et al. (1973, *Carex eleusinoides-Eriophorum scheuchzeri-Eriophorum angustifolium*). In Jasper, Kuchar (1975, *Eriophorum polystachion/Calliergon sarmentosum*) described a similar type. In British Columbia, Knapik and Landals (1974) described an *Eriophorum polystachion* type in Mount Revelstoke National Park and Kuchar (1978) described a similar cottongrass meadow in Yoho National Park.

H11: *Carex aquatilis-Carex rostrata*

(water sedge-beaked sedge)

Environment: The H11 fens occur on hydric to subhydric Montane to Upper Subalpine (1380-2220 m B, 1220-1880 m J) and occasionally Alpine (2290 m B) sites, in predominantly level situations. Soils are very poorly drained Terric Mesisols and Rego Gleysols developed on fluvial and to a lesser extent on morainal landforms.

Vegetation: Cover of the herb-dwarf shrub layer is high (50-85%, Plate 77) almost entirely *Carex aquatilis* (15-70%) and *Carex rostrata* (10-60%) (Table 87). *Carex physocarpa* can be dominant in some high elevation stands. *Equisetum fluviatile* may have high cover (20-55%) in some low elevation stands where water is slowly flowing. Aquatic plants such as *Lemna minor* and *Utricularia* spp. may be present but this v.t. is generally very species poor. Bryoid cover is moderate to high (50-85%) but can be quite variable among stands due to differences in moisture regime and flooding frequency. Species commonly represented are *Drepanocladus revolvens* (10-55%), *Tomenthypnum nitens* (up to 35% on hygric sites), *Campylium stellatum* (<15%), and *Bryum pseudotriquetrum* (<10%).

Table 87 Stands representing the water sedge-beaked sedge (H11) v.t.

	AW 70 98	IC 51 11	IC 70 67	IC 91 08	JD 60 39	JD 80 26	JD 80 82	KS 60 53	PA 71 34	PA 81 00
SHRUB LAYER										
Betula glandulosa	--	--	--	.5	--	--	.5	--	--	05
Betula pumila	--	--	--	--	05	--	--	--	--	--
Salix barrattiana	--	--	--	--	02	--	.5	--	--	--
Salix glauca	--	--	--	01	--	--	--	--	--	.5
Salix planifolia	--	05	--	--	--	--	.5	--	--	--
HERB-DWARF SHRUB LAYER										
Arctostaphylos rubra	--	--	--	03	--	--	--	--	--	--
Calamagrostis canadensis	--	03	--	--	--	--	--	--	--	--
Carex aquatilis	80	10	20	22	38	80	85	50	70	80
Carex capillaris	--	--	--	--	--	01	--	--	--	--
Carex rostrata	--	60	55	01	42	.5	--	10	--	--
Deschampsia caespitosa	--	--	--	--	03	.5	--	--	--	05
Equisetum arvense	--	--	--	--	--	--	--	02	--	--
Equisetum fluviatile	--	--	--	--	--	--	--	20	--	--
Erigeron peregrinus	--	--	--	--	03	--	--	--	--	--
Eriophorum angustifolium	--	--	--	--	--	--	--	--	01	--
Hierochloe odorata	--	--	--	--	02	--	--	--	--	--
Kobresia simpliciuscula	--	--	--	--	--	01	--	--	--	--
Pedicularis groenlandica	--	--	--	--	--	.5	--	--	03	--
Petasites sagittatus	--	--	--	--	01	--	--	06	--	--
Potentilla diversifolia	--	--	--	--	.5	--	--	--	.5	--
Potentilla fruticosa	--	--	--	.5	--	01	--	--	--	--
Pyrola asarifolia	--	.5	--	.5	--	--	--	--	--	--
Rubus acaulis	--	.5	--	.5	04	--	--	--	--	--
Salix barrattiana	--	--	--	--	--	02	--	--	--	--
Salix brachycarpa	--	--	--	--	--	05	--	--	--	--
Salix nivalis	--	--	--	--	--	--	--	--	05	--
Vaccinium caespitosum	--	--	--	01	--	--	--	--	--	--
BRYOID LAYER										
Aulacomnium palustre	--	--	--	--	10	--	--	--	05	40
Bryum pseudotriquetrum	05	--	--	05	02	10	.5	--	.5	--
Calliergon giganteum	.5	--	--	--	--	.5	--	.5	--	--
Campylium stellatum	--	--	--	.5	--	50	.5	15	.5	10
Catascopium nigritum	--	--	--	.5	--	.5	--	--	--	--
Cinclidium stygium	.5	--	--	.5	--	.5	--	--	--	--
Drepanocladus revolvens	85	--	--	55	--	.5	40	60	10	.5
Drepanocladus uncinatus	--	--	--	--	50	--	--	--	--	--
Meesia triquetra	02	--	--	--	--	.5	--	--	--	--
Mnium rugicum	--	--	--	--	03	--	--	--	--	--
Mnium sp.	--	--	--	--	--	10	05	--	--	--
Myurella julacea	--	--	--	--	--	20	--	--	--	--
Philonotis fontana	--	--	--	--	--	.5	--	--	01	--
Scorpidium scorpioides	--	--	--	.5	--	--	40	--	.5	--
Tomentypnum nitens	06	--	--	15	--	--	--	--	30	30
Tortula ruralis	03	--	--	--	--	--	--	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The H11 v.t. is successionally mature and is relatively stable. There is however the tendency for peat to accumulate over a period of several hundred years with the subsequent invasion of shrubs and trees.

The H11 v.t. is distinguished from other wet fen v.t.s by the dominance of the large sedges *Carex aquatilis* and *Carex rostrata*. Toward the periphery on higher, better drained sections, transitions to wet shrub types such as S1 and S7 may occur. The H11 v.t. seldom covers large areas away from floodplains where it may be extensive.

Other Studies: Similar types have been described from the southern Yukon (Orloci and Stanek 1979, *Carex-Equisetum*), northeastern British Columbia (Raup 1934, *Carex rostrata*), northern Alberta (Lewis et al. 1928, *Carex aquatilis*), and southward along the Rocky Mountains. In Jasper, Kuchar (1972) described *Carex aquatilis* wet meadow in the Athabasca Valley and Crack (1977) described a *Carex aquatilis* type in Wilcox Pass. In the Kananaskis area, similar types were described by Kondla (1978, *Carex aquatilis* wetland), in Yoho National Park by Kuchar (1978, tall sedge meadow), and by Kuchar (1973) in Waterton Lakes National Park (sedge meadow).

H12: Saxicolous lichen

(saxicolous lichen)

Environment: The H12 v.t. occurs on subxeric to xeric Alpine sites (2400-2800 m) on various slopes and aspects. The soils are Orthic Regosols or nonsoil occurring on the Miscellaneous Landscapes Rockland (R) and Colluvial Rubble (CR).

Vegetation: The H12 v.t. is extremely sparsely vegetated (Plate 78). Total plant cover is commonly <20% with lichens contributing most cover (Table 88). Species usually have <1% cover. Common vascular plants are *Silene acaulis*, *Saxifraga oppositifolia*, *Selaginella densa*, *Oxytropis podocarpa*, *Draba incerta*, and *Salix nivalis*. All have a prostrate, cushion growth form. Important lichens include *Rhizocarpon geographicum*, *Xanthoria elegans*, *Sporastatia testudinea*, *Cetraria tilesii*, *Cetraria nivalis*, *Acarospora chlorophana*, *Cladonia pyxidata*, *Dactylina ramulosa*, *Lecanora melanophthalma*, *Rhizocarpon disporum*, *Umbilicaria virginis*, and *Thamnolia subuliformis*. A few mosses are sometimes present, including *Hypnum revolutum*, *Tortula ruralis*, and *Bryum* spp..

This v.t. is characteristic of weakly or noncalcareous sites and is mature successionally.

The H12 v.t. is distinguished by its very low plant cover, which is dominated by lichens

and occurrence at elevations above most other v.t.s.

Table 88 Stands representing the saxicolous lichen (H12) v.t.

	JE 81 17	JE 90 21	JE 90 56	JE 91 52	PA 70 21	PA 90 01
HERB-DWARF SHRUB LAYER						
Carex spp.	--	.5	02	.5	01	--
Draba incerta	--	--	--	--	.5	.5
Oxytropis podocarpa	--	--	--	--	.5	03
Salix nivalis	--	--	.5	.5	02	--
Saxifraga oppositifolia	--	.5	03	--	01	.5
Silene acaulis	--	.5	02	01	.5	05
Trisetum spicatum	--	--	--	.5	--	01
Selaginella densa	--	--	.5	.5	.5	.5
BRYOID LAYER						
Bryum spp.	--	--	.5	.5	.5	.5
Cetraria ericetorum	.5	.5	.5	--	--	--
Cetraria nivalis	--	.5	01	--	.5	02
Cetraria tilesii	.5	03	01	--	01	03
Cladonia pyxidata	--	--	.5	01	.5	--
Dactylina ramulosa	.5	.5	.5	--	.5	--
Dermatocarpon reticulatum	--	--	.5	--	--	--
Dimelaena oreina	.5	--	--	--	--	--
Distichium capillaceum	--	.5	.5	--	--	.5
Ditrichum flexicaule	--	.5	--	.5	.5	--
Hypnum revolutum	.5	.5	.5	.5	.5	--
Lecanora spp.	05	.5	.5	.5	--	--
Physconia muscigena	--	01	01	--	.5	--
Rhizocarpon disporum	.5	--	.5	02	--	--
Rhizocarpon geographicum	03	--	.5	08	--	--
Sporoastia testudinea	.5	--	.5	.5	--	--
Thamnolia subuliformis	--	.5	.5	--	.5	03
Tortula ruralis	--	.5	.5	.5	.5	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Other Studies: Beder (1967) described a similar type (ridge summit type) in Banff. In Jasper, similar types have been described by Crack (1977, high altitude open vegetation), Hettinger (1975, rock and lichen), Hrapko and La Roi (1978, *Potentilla nivea-Silene acaulis*), Kuchar (1975, cushion-rosette, lichen tundra), and La Roi (1975, *Silene acaulis/Alectoria*). Elsewhere in Alberta, similar types have been described by Ogilvie (1976, Kirby and Ogilvie 1969, stonefield-lichen), Jacques and Legge (1974, bare rock-lichen), Bryant and Scheinberg (1970), Kuchar (1973, saxicolous lichen tundra), and Kondla (1978, lichen dominated type). In British Columbia, Raup (1934) and, in Yoho National Park, Kuchar (1978, lichen tundra, boulder and rock tundra) have described similar types.

H13: *Stipa richardsonii-Koeleria cristata-Antennaria nitida*

(Richardson needlegrass-junegrass-everlasting)

Environment: The H13 grasslands occur on subxeric to xeric Montane (1250-1670 m), level to gently sloping sites of southerly aspect. Soils are rapidly to well drained Orthic Regosols and Orthic Eutric Brunisols developed on glaciofluvial, fluvial, colluvial, and glacial landforms.

Vegetation: *Stipa richardsonii* (5-20%) is the dominant plant (Table 89). *Koeleria cristata* is usually less abundant (2-10%). Other characteristic species are *Antennaria nitida* (<8%), *Anemone multifida* (<5%), *Selaginella densa* (5%), *Penstemon confertus* (<3%), and *Galium boreale* (<2%). *Festuca scabrella* is present in several Banff stands. Total cover of the herb-dwarf shrub layer is 65 to 100%, the majority being due to grasses (Plate 79). The bryoid layer is sparse, dominated by *Cetraria* spp. (<5%). H13 is often associated with scattered shrubs and as small areas within and bordering lodgepole pine (C3) and Douglas fir (C1) forests.

Table 89 Stands representing the Richardson needlegrass-junegrass-everlasting (H13) v.t.

	AW 51 50	IC 70 10	KS 50 41	KS 51 10	KS 51 12	KS 51 63
SHRUB LAYER						
Elaeagnus commutata	--	--	--	--	--	03
Potentilla fruticosa	.5	--	--	--	02	.5
Rosa acicularis	.5	--	.5	02	--	--
HERB-DWARF SHRUB LAYER						
Achillea millefolium	--	--	--	01	02	--
Agropyron bakeri	--	--	15	--	--	--
Agropyron subsecundum	--	--	15	--	--	--
Agropyron spp.	.5	--	--	05	--	--
Anemone multifida	.5	05	.5	--	02	05
Anemone patens	--	--	--	05	--	--
Antennaria nitida	.5	08	.5	03	01	04
Arctostaphylos uva-ursi	--	--	--	--	03	--
Aster alpinus	.5	--	--	--	05	03
Aster ciliolatus	--	--	--	--	06	.5
Astragalus flexuosus	--	--	15	--	--	--
Astragalus striatus	06	--	--	--	--	--
Bromus ciliatus	01	--	--	--	05	.5
Campanula rotundifolia	01	--	--	--	.5	.5
Cerastium arvense	01	.5	.5	--	--	.5
Danthonia intermedia	--	--	--	20	--	.5
Elymus innovatus	--	--	--	02	--	--
Erigeron caespitosus	--	05	--	--	--	--
Erigeron compositus	--	05	--	--	--	--
Eriogonum subalpinum	--	--	--	03	--	--
Festuca saximontana	42	--	--	--	05	--
Festuca scabrella	05	--	--	.5	20	--
Galium boreale	01	--	--	01	02	.5
Geum triflorum	.5	.5	--	02	--	--
Koeleria cristata	02	02	10	05	03	25
Linum lewisii	--	--	--	--	01	05
Oxytropis campestris	04	--	--	--	--	03
Penstemon confertus	.5	--	03	03	.5	--
Senecio canus	--	--	.5	--	01	.5
Senecio cymbalarioides	--	02	--	--	--	--
Sisyrinchium montanum	--	02	--	--	--	.5
Stellaria spp.	--	05	--	--	--	--
Stipa richardsonii	.5	08	15	20	08	45
Taraxacum officinale	.5	.5	--	--	--	.5
Selaginella densa	06	15	04	.5	--	--
BRYOID LAYER						
Cetraria ericetorum	--	05	--	--	--	--
Cetraria islandica	02	--	--	--	05	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Successionally, H13 is mature.

The H13 v.t. is distinguished from H6 by the dominance of *Stipa richardsonii* rather than of *Koeleria cristata*.

Other Studies: Stringer (1973) described simi-

lar vegetation (*Stipa richardsonii* shrub savanna) in Banff and Jasper.

H14: *Elymus innovatus-Koeleria cristata-Arctostaphylos uva-ursi*

(hairy wild rye-junegrass-bearberry)

Environment: The H14 grasslands occur on subxeric Lower to Upper Subalpine (1600-2300 m B, 1800-2200 m J), steeply sloping sites of southerly aspect, mostly in the Front Ranges of eastern Banff and Jasper. Soils are rapidly to well drained Orthic Melanic and Orthic Eutric Brunisols, and Orthic Humic Regosols developed on colluvial and morainal landforms.

Table 90 Stands representing the hairy wild rye-junegrass-bearberry (H14) v.t.

	IC 60 57	IC 60 31	JB 80 17	JB 80 19	JE 81 14	KS 60 36	PA 80 02	PA 81 22	PA 81 42	PA 81 91
	HERB-DWARF SHRUB LAYER									
Achillea millefolium	01	02	.5	.5	.5	10	01	--	.5	01
Agoseris glauca	--	--	--	--	--	--	02	--	.5	.5	--
Agropyron spicatum	--	--	--	--	--	--	--	--	--	--	15
Agropyron trachycaulum	--	--	--	--	--	.5	01	--	--	--	--
Allium cernuum	--	.5	--	.5	.5	02	01	--	--	--	--
Androsace septentrionalis	01	--	.5	.5	--	.5	01	.5	02	.5	
Anemone multifida	01	--	--	--	.5	01	--	.5	01	10	
Antennaria nitida	10	.5	02	03	10	01	15	05	10	--	
Arctostaphylos uva-ursi	--	.5	--	--	--	--	--	01	02	--	
Arenaria rubella	--	--	--	--	--	--	03	--	--	.5	
Artemisia frigida	--	--	--	--	.5	--	--	.5	--	--	
Aster alpinus	--	--	--	--	--	--	--	.5	--	.5	
Aster ciliolatus	--	.5	.5	--	--	--	--	--	--	--	
Astragalus alpinus	01	20	.5	--	.5	02	05	10	.5	05	
Bromus pumpellianus	--	--	--	--	--	--	--	05	--	--	
Calamagrostis purpurascens	--	--	--	--	--	--	08	--	--	--	
Calamagrostis spp.	--	--	.5	.5	.5	.5	--	.5	03	.5	
Campanula rotundifolia	--	--	03	--	--	--	--	--	--	--	
Carex phaeocephala	--	--	.5	--	--	--	--	--	02	--	
Castilleja occidentalis	--	02	08	--	.5	08	--	--	03	--	
Cerastium arvense	--	.5	03	--	--	--	--	--	--	--	
Delphinium glaucum	35	30	60	15	15	15	20	15	50	05	
Deschampsia atropurpurea	01	02	--	--	--	--	--	02	--	--	
Elymus innovatus	--	--	--	--	--	--	02	--	--	--	
Epilobium angustifolium	--	--	--	--	--	--	--	01	.5	--	
Erigeron caespitosus	01	02	.5	--	--	02	--	.5	02	--	
Festuca scabrella	--	--	--	.5	02	.5	01	.5	.5	--	
Fragaria virginiana	--	.5	--	--	.5	.5	--	01	--	--	
Gallium boreale	01	01	--	--	08	--	01	--	--	--	
Gentiana amarella	--	--	08	15	--	02	.5	03	20	10	
Hedysarum alpinum	--	--	--	--	--	--	.5	.5	--	--	
Hedysarum sulphurescens	--	--	--	--	--	--	--	.5	--	--	
Juniperus communis	--	--	08	--	--	--	--	.5	--	--	
Juniperus horizontalis	25	10	01	10	10	20	05	20	05	25	
Koeleria cristata	--	--	08	--	--	--	--	.5	--	--	
Myosotis alpestris	--	--	01	.5	01	--	--	--	--	--	
Oxytropis campestris	--	--	.5	.5	--	.5	--	01	02	.5	
Oxytropis splendens	--	08	--	--	--	--	--	01	--	--	
Oxytropis spp.	--	--	--	--	--	.5	--	--	03	--	
Penstemon confertus	.5	.5	--	--	.5	--	--	--	--	--	
Penstemon procerus	--	02	.5	--	--	.5	--	01	--	.5	
Phacelia sericea	--	--	--	--	--	--	--	02	--	03	
Poa cusickii	--	--	--	--	--	06	--	--	--	--	
Poa epilis	--	--	--	--	--	.5	--	--	04	.5	
Poa interior	05	.5	15	.5	--	--	--	--	--	--	
Poa spp.	--	.5	02	--	.5	--	--	.5	--	--	
Potentilla diversifolia	.5	--	05	01	02	--	.5	.5	--	.5	
Potentilla fruticosa	.5	--	--	--	--	.5	01	--	02	--	
Rosa acicularis	--	--	--	.5	--	--	--	--	.5	--	
Rhinanthus crista-galli	--	--	.5	--	--	.5	--	.5	.5	.5	
Sedum stenopetalum	01	01	--	--	--	--	--	--	--	--	
Solidago decumbens	--	--	03	--	--	--	--	.5	.5	--	
Solidago multiradiata	--	--	.5	--	--	--	--	.5	--	--	
Stellaria longipes	--	--	--	--	05	--	--	--	--	--	
Vicia americana											
	BRYOID LAYER									
Candellariella aurella	--	--	.5	.5	--	--	.5	--	--	--	
Grimmia anodon	--	--	--	.5	--	--	.5	--	--	--	
Hypnum revolutum	--	.5	--	.5	--	--	--	--	--	--	
Peltigera rufescens	--	.5	--	--	--	--	--	--	.5	--	
Physconia muscigena	--	--	--	.5	--	--	.5	--	--	--	
Tortula ruralis	--	.5	01	.5	--	.5	--	.5	--	.5	
Xanthoria elegans	--	--	--	.5	--	--	.5	--	--	--	

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: Shrub cover is low (generally <5% but occasionally >15%) with *Potentilla fruticosa* and *Salix glauca* being the most frequent representatives. The herb-dwarf shrub layer (Plate 80) has high cover (60-100%) and is dominated by *Elymus innovatus* (5-50%), *Koeleria cristata* (5-35%), and *Arctostaphylos uva-ursi* (5-20%) (Table 90). *Hedysarum sulphurescens* (5-15%) is often abundant in Banff. Other species usually present are *Bromus pumpellianus* (1-10%), *Achillea millefolium* (1-2%), *Fragaria virginiana* (<10%), *Anemone multifida* (<10%), *Cerastium arvense* (<10%), *Oxytropis splendens* (1%), *Myosotis alpestris* (1-5%), *Antennaria nitida/rosea* (1-2%), *Campanula rotundifolia* (<3%), and *Poa cusickii/spp.* (<1-5%). The bryoid layer has low cover (<10%) and *Tortula ruralis* (<5%) is the dominant.

Successionally, H14 is mature.

The H14 v.t. is distinguished from H4 by the absence in the former of *Dryas octopetala*, the presence of much more *Elymus innovatus*, and by generally lower elevations. Stands transitional to H4 occur. The H14 v.t. is distinguished from H5 by more abundant *Koeleria cristata*, *Hedysarum* spp., *Bromus pumpellianus* and *Arctostaphylos uva-ursi* reflecting the generally drier conditions in H14. The higher elevations of H14 separate it from low elevation grasslands such as H6, H7, and H13. Stands with abundant *Potentilla fruticosa* and low grass cover are transitional to L1.

Other Studies: Similar types have been described in Banff and Jasper by Stringer (1973, *Elymus innovatus* shrub savanna) and Beder (1973, *Elymus innovatus*). Ogilvie (1976, Kirby and Ogilvie 1969, *Elymus innovatus*) has also described a similar type. In the Porcupine Hills, similar grasslands have been described by Ogilvie (1971).

H15: *Dryas integrifolia-Carex rupestris*

(mountain avens-curly sedge)

Environment: The H15 v.t. occurs on subhygric, Upper Subalpine (1900 m) steeply sloping (90%) slopes of easterly aspect in the Columbia Icefields area of Jasper on failed morainal landforms. Soils are Orthic Eutric Brunisols and Orthic Regosols. Nearly 40% of the ground surface is unvegetated.

Vegetation: *Dryas integrifolia* (10%) and *Carex rupestris* (20%) are the dominant plants (Table 91). Other characteristic species are *Carex scirpoidea* (3%), *Carex albo nigra* (3%), *Cassiope tetragona* (3%), *Ledum groenlandicum* (2%), and *Arctostaphylos rubra* (1%). Total vascular plant cover which is confined to the herb - dwarf shrub layer is <50%. The bryoid layer has low cover with traces of *Cetraria* spp..

Table 91 Stands representing the mountain avens -curly sedge (H15) v.t.

	1C
	61
	37
	.5
HERB-DWARF SHRUB LAYER	
Arctostaphylos rubra	01
Betula glandulosa	.5
Carex albo-nigra	03
Carex rupestris	20
Carex scirpoidea	02
Cassiope tetragona	03
Draba spp.	.5
Dryas integrifolia	10
Ledum groenlandicum	02
Parnassia spp.	.5
Potentilla fruticosa	.5
Salix vestita	01
Saxifraga aizoides	.5
Saxifraga oppositifolia	.5
Tofieldia glutinosa	01
BRYOID LAYER	
Cetraria tilesii	.5
Cetraria spp.	01

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The H15 v.t. is successionally mature, its treeless character maintained by active soil creep.

The H15 v.t. appears to be very limited in extent, with only one plot sampled, but its similarity with some Front Range and subarctic communities make it worthy of note. It is not a significant component in any Ecosite, but is readily visible from Highway 93 about 1 km north of Athabasca Glacier on the west side of the Sunwapta River.

The H15 v.t. is distiguished from H1 by having abundant *Carex rupestris*, wetter site conditions, and steeper slopes.

Other Studies: In Alberta, *Dryas integrifolia-Carex rupestris* types have been described only from the Front Ranges of the Rocky Mountains by Mortimer (1978) and See and Bliss (1980). Bamberg and Major (1968) described a *Dryas integrifolia-Carex rupestris* dominated community in the Big Snowy Mountains of central Montana.

H16: *Erigeron peregrinus-Valeriana sitchensis*

(fleabane-valerian)

Environment: The H16 v.t. occurs on subhygric to mesic Upper Subalpine sites (1950-2350 m) on various slopes and aspects. The soils are imperfectly to well drained Dystric Brunisols, Gleysols, and Regosols on fluvial and morainal landforms.

Vegetation: The H16 v.t. is a species rich herb meadow (Plate 81). Total herb-dwarf shrub layer cover is 70 to 100% with *Erigeron peregrinus* (5-20%), *Valeriana sitchensis* (5-20%), *Trollius albiflorus* (5-20%), and *Anemone occidentalis* (5-15%) dominant (Table 92). Other important species are *Senecio triangularis* (1-10%), *Antennaria lanata* (1-5%), *Artemisia norvegica* (Jasper) (1-5%), *Pedicularis bracteosa* (<1-3%), *Salix arctica* (1-5%), and *Potentilla diversifolia* (<1-2%). Common species with low cover include *Carex nigricans*, *Sibbaldia procumbens*, *Phleum alpinum*, *Veronica alpina*, and *Poa alpina*. Bryoid cover is variable but usually <15% with the mosses *Pseudoleskea radicosa*, *Tortula ruralis*, *Aulacomnium palustre*, and *Bryum pseudotriquetrum* most common.

Table 92 Stands representing the fleabane-valerian (H16) v.t.

	1C	2C	2D	2E	8S	1C	PA	9A	PA	5C
	91	61	66	90	5.	01	71	--	--	9.
	36	2*	36	90	*.	66	8	6	5C	*.
HERB-DWARF SHRUB LAYER										
Anemone occidentalis	15	10	10	05	06	--	15	--	10	08
Antennaria lanata	08	.5	20	--	25	--	.5	05	02	.5
Arnica latifolia	--	--	01	--	01	--	--	03	.5	--
Artemisia norvegica	05	10	--	05	--	06	--	--	--	--
Caltha leptosepala	--	02	--	--	--	15	--	01	--	.5
Carex nigricans	02	01	.5	--	01	02	.5	--	--	--
Castilleja spp.	--	--	03	--	15	02	02	03	01	01
Erigeron peregrinus	05	06	05	30	15	10	20	20	10	07
Erythronium grandiflorum	--	--	15	--	--	--	15	--	.5	--
Pedicularis bracteosa	--	02	--	15	--	01	01	03	--	12
Phleum alpinum	01	--	03	--	.5	.5	--	--	02	--
Phyllodoce glanduliflora	.5	03	02	--	--	--	03	05	--	--
Poa alpina	01	01	01	--	.5	--	.5	--	--	--
Polygonum viviparum	--	02	--	--	--	01	--	02	.5	.5
Potentilla diversifolia	02	.5	01	--	01	01	01	02	.5	07
Salix arctica	--	05	--	--	--	--	02	05	05	01
Senecio triangularis	15	03	--	15	--	10	--	.5	02	--
Trollius albiflorus	05	15	03	10	06	10	10	30	15	15
Vaccinium scoparium	--	03	05	--	10	--	.5	.5	.5	--
Valeriana sitchensis	10	01	10	10	06	10	01	03	15	15
Veronica alpina	.5	02	01	.5	04	01	.5	--	--	--
BRYOID LAYER										
Aulacomnium palustre	--	--	--	--	10	60	--	--	--	--
Desmatodon latifolius	.5	--	--	--	.5	--	.5	--	--	--
Pseudoleskea radicosa	.5	--	--	--	.5	--	--	--	--	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

The H16 v.t. is mature successionally.

The H16 v.t. has many species in common with L7. The L7 v.t., however, is dominated by *Salix arctica* and the characteristic H16 species *Valeriana sitchensis*, *Trollius albiflorus*, and *Anemone occidentalis* are generally absent or with low cover in L7. The H2 v.t. differs in having *Carex nigricans* dominant.

Other Studies: In Banff, similar types have been described by Broad (1973, *Anemone occidentalis-Thalictrum occidentale*) and Trottier and Scotter (1973, *Senecio triangularis-Caltha leptosepala-Trollius albiflorus-Erigeron peregrinus, Anemone occidentalis-Valeriana sitchensis-Veratrum eschscholtzii*). Similar types have been described in Jasper by Kuchar (1975, *Artemisia norvegica/Salix arctica*) and La Roi (1975, *Valeriana sitchensis/Cassiope mertensiana/Orthocaulis floerkii*).

Elsewhere in Alberta, Jacques and Legge (1974, meadow rue), Trottier (1972, *Thalictrum occidentale*), and Kuchar (1973, moist forb meadow) have described similar types. In British Columbia, similar types have been described by Knapik and Landals (1974, *Valeriana sitchensis-Luzula glabrata*) in Mount Revelstoke National Park and by Kuchar (1978, moist forb meadow) in Yoho National Park. Choate and Habeck (1967) and Habeck (1969) described a similar type in Glacier National Park, Montana.

H19: *Agropyron spicatum-Elymus innovatus-Aster conspicuus*

(bluebunch wheatgrass-hairy wild rye-showy aster)

Environment: The H19 grasslands occur on xeric Montane to Lower Subalpine (1400-1700 m) moderately steep sites of southwest aspect in Banff. Soils are predominanty rapidly drained Orthic Regosols on colluvial and glacial landforms.

Table 93 Stands representing the bluebunch wheatgrass-hairy wild rye-showy aster (H19) v.t.

	RS 50 04	RS 90 06	RS 90 07	RS 90 08
SHRUB LAYER				
Juniperus communis	--	02	--	--
Rosa acicularis	02	--	02	--
HERB-DWARF SHRUB LAYER				
Achillea millefolium	01	02	05	.5
Agropyron spicatum	15	30	--	30
Agropyron spp.	--	--	20	--
Agrostis spp.	--	--	05	--
Allium cernuum	--	--	02	--
Androsace septentrionalis	--	.5	--	--
Anemone multifida	.5	--	--	--
Antennaria nitida	.5	.5	.5	.5
Antennaria rosea	--	.5	02	--
Aquilegia flavescens	.5	--	--	--
Arabis lyallii	--	.5	--	--
Artemisia michauxiana	01	04	--	15
Aster conspicuus	03	05	05	--
Astragalus tenellus	--	--	.5	--
Carex sprengelii	--	04	--	--
Cerastium arvense	.5	02	--	01
Cirsium hookerianum	.5	.5	--	--
Collinsia parviflora	--	.5	--	--
Cystopteris fragilis	--	.5	--	--
Elymus innovatus	30	10	08	--
Epilobium angustifolium	.5	.5	--	--
Erysimum inconspicuum	.5	--	--	--
Fragaria virginiana	--	02	--	--
Galium boreale	--	01	--	.5
Hedysarum sulphurescens	--	.5	--	--
Heuchera cylindrica	--	.5	--	--
Koeleria cristata	--	03	10	08
Myosotis alpestris	01	02	--	--
Oxytropis splendens	08	02	.5	--
Oxytropis viscida	--	--	.5	--
Penstemon confertus	--	08	.5	--
Poa epilis	08	--	--	--
Potentilla gracilis	--	.5	--	--
Potentilla pensylvanica	--	.5	--	--
Rosa acicularis	--	--	--	.5
Selaginella dense	--	.5	--	--
Stipa columbiana	--	--	15	--
Vicia americana	--	--	.5	--

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: Shrub cover is low and is confined to sporadic occurrences of *Juniperus communis* and *Rosa acicularis*. The dense (50-85%) herb-dwarf shrub layer is comprised of the dominants *Agropyron spicatum* (15-30%), *Elymus innovatus* (10-30%), and *Koeleria cristata* (3-10%) (Table 93). Other characteristic species include *Aster conspicuus* (3-5%), *Oxytropis splendens* (<8%), *Antennaria nitida/rosea* (<2%), and *Cerastium arvense* (<2%). The bryoid layer has very little or no cover, with no evident dominants.

Successionally H19 is mature, the community being maintained by the droughty southerly aspects. H19 is not a significant component in any Ecosite and appears to be very limited in extent, the three sampled plots occurring on slopes above Hillsdale meadow in Banff, but its similarity to more southerly grasslands makes it worthy of note.

The H19 v.t. is distinguished from other grassland v.t.s (H4, H5, H6, H7, H13, and H14) by the dominance of *Agropyron spicatum*, or codominance with *Elymus innovatus*. Stands with low *Agropyron* cover are transitional to H14.

Other Studies: A similar type was described in Montana by Mueggler and Stewart (1980, *Festuca scabrella/Agropyron spicatum*). *Elymus innovatus* in Banff substitutes for *Festuca scabrella* in Montana.

H20: *Saxifraga bronchialis-Elymus innovatus*

(spotted saxifrage-hairy wild rye)

Environment: The H20 v.t. occurs on subxeric to xeric, Upper Subalpine (1950-2200 m) sites on steep southerly slopes. The soils are rapidly to very rapidly drained Orthic Regosols on colluvial landforms.

Table 94 Stands representing the spotted saxifrage-hairy wild rye (H20) v.t.

	AW 50 24	AW 71 05	JC 60 44	JD 90 01	SJ 80 28
HERB-DWARF SHRUB LAYER					
Achillea millefolium	.5	.5	--	.5	.5
Anemone multifida	--	.5	--	.5	--
Arctostaphylos uva-ursi	--	--	40	--	--
Carex spp.	02	.5	--	.5	--
Elymus innovatus	.5	--	05	--	04
Epilobium angustifolium	--	.5	--	--	02
Festuca spp.	--	.5	30	.5	04
Fragaria virginiana	.5	.5	--	--	--
Hedysarum mackenzii	01	--	--	--	04
Juniperus communis	.5	02	--	--	.5
Poa spp.	.5	--	02	--	.5
Potentilla nivea	--	--	.5	.5	02
Saxifraga bronchialis	--	03	02	50	13
Silene acaulis	--	--	--	05	.5
Zygadenus elegans	01	--	--	01	06
BRYOID LAYER					
Tortula ruralis	--	.5	--	02	.5
Bryum spp.	--	--	--	01	--
Hypnum spp.	--	--	--	--	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation: The composition of H20 is heterogeneous. Common species include *Saxifraga bronchialis*, *Elymus innovatus*, *Potentilla nivea*, *Achillea millefolium*, *Festuca saximontana*, *Zygadenus elegans*, and *Tortula ruralis* (Table 94). Total vegetation cover is typically low (<50%) and patchy reflecting the harsh environmental conditions (Plate 185). In addition to being dry and having little soil development, many H20 stands are subject to snow avalanching.

The H20 v.t. is mature successionally.

The H20 v.t. is distinguished from H12 by having lower elevation, lower lichen cover, and greater vascular plant cover.

Other Studies: The "rock outcrop association" described by Kondla (1978) for the Kananaskis area is similar.

KEY TO VEGETATION TYPES
P.L. Achuff

USE OF THE KEY

The term "dominant" (species with the highest % cover) is used in the key, but "abundant" can usually be substituted. Occasionally, species other than those in the key leads may be dominant. In such cases, use the species in the key leads which is most abundant. For example, in a *Pinus contorta/Shepherdia canadensis* closed forest (lead 8) *Elymus innovatus* (35%) may be dominant with *Linnaea borealis* (5%), *Aster conspicuus* (2%) and *Vaccinium scoparium* (25%). *Elymus innovatus* is dominant but not in the key leads. Therefore, use the most abundant species which is in the leads, which is *Vaccinium scoparium* and the stand keys to C18.

The following general cover value terms are used but should not be rigidly interpreted: sparse <15%, moderate 15-50%, and dense >50%. Often the cover of a species relative to other species in the stand is a better guide to its significance than the absolute cover values. Polychotomous leads have been used to save space and simplify the key. Alternative leads are grouped to minimize confusion.

Not all stands will key to a v.t.; intermediates occur and heterogeneous stands may be virtually unclassifiable, although their affinities may be apparent. The descriptions contain additional information and comments on related v.t.s which will help better place the stand in question. The key is only an aid to classification. Always consult the v.t. description to validate the determination.

KEY TO PHYSIOGNOMIC GROUPS

1a. Vegetation with trees ≥ 5m tall and tree cover >5 % 2
1b. Vegetation without trees ≥5m tall or tree cover <5 % 3
2a. Distance between tree crowns < 2X crown width, total tree cover usually >20% (some Open Forest stands with 15-20% tree cover may key here) ..... Closed Forest(C), I
2b. Distance between tree crowns 2-5X crown width, total tree cover usually ≤20%, (some sparse Closed Forest stands with <20% cover may key here) ..... Open Forest(O), II
3a. Vegetation dominated by shrubs ≥0.5-5m tall ..... Shrub(S), III
3b. Vegetation dominated by plants ≤0.5m tall 4
4a. Vegetation dominated by low shrubs (0.1-0.5m tall) and herbs ..... Low Shrub(L), IV
4b. Vegetation dominated by dwarf shrubs (<0.1m tall) or herbs ..... Herb-Dwarf Shrub(H), V

I. KEY TO CLOSED FOREST VEGETATION TYPES

1a. Dominant trees broad-leaved 2
1b. Dominant trees needle-leaved 5
2a. Dominant tree *Populus tremuloides* 3
2b. Dominant tree *Populus balsamifera* 4
3a. *Lathyrus ochroleucus* and *Galium boreale* > *Aster conspicuus*, landform fluvial C16
3b. *Aster conspicuus* > *Lathyrus ochroleucus* and *Galium boreale*, landform colluvial C22
4a. *Shepherdia canadensis* and *Elymus innovatus* dominant, site mesic C17
4b. *Shepherdia canadensis* not dominant, *Equisetum* spp. dominant herbs, site hygric to subhygric C28
5a. Dominant tree *Larix lyallii*, occasionally codominant with *Abies lasiocarpa* (some stands may have open canopy) C23

5b. Dominant tree *Pseudotsuga menziesii* (if codominant with *Picea glauca*, see C5) C1

5c. Dominant tree *Picea mariana*, *Pinus contorta* may be codominant C8

5d. Dominant trees *Picea engelmannii* and *Pinus albicaulis* C12

5e. Dominant tree *Pinus contorta*, *Picea* spp. may be codominant 6

5f. Dominant tree *Picea* spp., *Abies lasiocarpa* may be codominant 11

6a. Dominant shrub *Menziesia glabella* C20

6b. Dominant shrub *Alnus crispa* C10

6c. Dominant shrub *Salix glauca* C36

6d. Dominant shrub *Ledum groenlandicum* C29

6e. Dominant shrub *Juniperus communis* C3

6f. Dominant shrub *Shepherdia canadensis* 7

6g. Shrub layer sparse, may have well developed dwarf shrub layer 9

7a. *Aster conspicuus* 10-20%, site mesic C6

7b. *Aster conspicuus* <10%, site various 8

8a. Dominant dwarf shrub *Vaccinium scoparium* C18

8b. Dominant dwarf shrub *Linnaea borealis* C19

9a. Herb-dwarf shrub layer sparse, bryoid layer well developed with *Hylocomium splendens* and *Pleurozium schreberi* dominant, site mesic C11

9b. Herb-dwarf shrub layer moderate to dense, sites mesic or subxeric 10

10a. *Vaccinium caespitosum* dominant dwarf shrub, *Cladonia* spp. <25%, site mesic to subxeric C9

10b. *Empetrum nigrum* dominant dwarf shrub, *Cladonia* spp. >25%, site subxeric C35

10c. *Juniperus communis* and *Arctostaphylos uva-ursi* dominant dwarf shrubs, site subxeric C3

11a. Herb-dwarf shrub layer dominated by *Equisetum* spp. 12

11b. Herb-dwarf shrub layer not dominated by *Equisetum* spp. 13

12a. Shrub layer dense, dominated by *Rosa acicularis*; *Arnica cordifolia*, *Elymus innovatus* and *Mertensia paniculata* usually absent, Montane, site subhygric to hygric, *Picea* usually *Picea glauca* C4

12b. Shrub layer sparse, *Rosa acicularis* usually absent; *Arnica cordifolia*, *Elymus innovatus* and *Mertensia paniculata* usually present, Lower Subalpine, site mesic to subhygric, *Picea* usually *Picea engelmannii* C32

13a. Shrub layer dominated by *Rosa acicularis*, Jasper only C27

13b. Shrub layer dominated by *Menziesia glabella* C14

13c. Shrub layer dominated by *Vaccinium membranaceum* (or *Rhododendron albiflorum*) C21

13d. Shrub layer dominated by *Salix vestita*, *Cassiope tetragona* present C24

13e. Shrub layer dominated by *Ledum groenlandicum*, *Empetrum nigrum* usually present C30

13f. Shrub layer dominated by *Shepherdia canadensis* 14

13g. Shrub layer sparse 15

14a. *Thuidium abietinum* dominant bryophyte C26

14b. *Hylocomium splendens* dominant bryophyte C37

15a. *Thuidium abietinum* dominant bryophyte, Jasper only C2

15b. *Thuidium abietinum* not dominant bryophyte, both Banff and Jasper 16

16a. *Vaccinium membranaceum* dominant dwarf shrub, *Barbilophozia lycopodioides* dominant bryophyte C21

16b. *Vaccinium membranaceum* not dominant dwarf shrub, *Hylocomium splendens* (occasionally *Pleurozium schreberi* or *Dicranum* spp.) dominant bryophyte 17

17a. Herb-dwarf shrub layer cover <15%, *Vaccinium scoparium* usually absent, Lower Subalpine C13

17b. Herb-dwarf shrub layer cover >15%, *Vaccinium scoparium* usually present, Lower or Upper Subalpine 18

18a. Herb-dwarf shrub layer dominated by *Phyllodoce glanduliflora* (or sometimes *Phyllodoce empetriformis*), herb cover low, Upper Subalpine C34

18b. Herb-dwarf shrub layer dominated by *Elymus innovatus*, *Arnica cordifolia* and *Linnaea borealis*, herb cover high, Lower Subalpine C31

18c. Herb-dwarf shrub layer dominated by *Vaccinium scoparium*, herb cover variable, Upper Subalpine C15

II. KEY TO OPEN FOREST TYPES

1a. Tree layer dominated by *Pinus flexilis*, often with *Pseudotsuga menziesii* O2

1b. Tree layer dominated by *Pseudotsuga menziesii* O5

1c. Tree layer dominated by mixture of *Picea* spp., *Abies lasiocarpa*, *Pinus albicaulis* and *Pinus contorta*; *Pseudotsuga menziesii* may be present at lower altitudes; usually on steep, colluvial, subxeric site (some open C35 may key here) O4

1d. Tree layer dominated by *Betula* spp. O16

1e. Tree layer dominated by *Picea glauca* and *Picea mariana* O7

1f. Tree layer dominated by *Pinus contorta* with prominent *Juniperus communis* and *Arctostaphylos uva-ursi* in understory ..... open variant of C3

1g. Tree layer dominated by *Picea glauca* or *Picea engelmannii*, *Abies lasiocarpa* may be codominant 2

2a. *Ledum groenlandicum* dominant shrub O11

2b. *Salix* spp. dominant shrub 3

2c. *Potentilla fruticosa* dominant shrub O3

2d. *Juniperus communis* dominant shrub O17

2e. Shrub layer sparse or dominated by tree regeneration 6

3a. *Salix vestita* dominant shrub 4

3b. Dominant shrub *Salix* spp. other than *Salix vestita* 5

4a. *Arctostaphylos rubra* dominant in herb-dwarf shrub layer O12

4b. *Pedicularis bracteosa* dominant in herb-dwarf shrub layer O14

5a. *Elymus innovatus* dominant herb, site mesic O18

5b. *Carex* spp. dominant herb, site hygric to hydric O6

6a. Herb-dwarf shrub layer dominated by *Dryas octopetala* O19

6b. Herb-dwarf shrub layer dominated by *Phyllodoce glanduliflora*, *Cassiope mertensiana* or other ericaceous dwarf shrubs O10

6c. Herb-dwarf shrub layer dominated by *Valeriana sitchensis*, *Erigeron peregrinus* or other herbs O9

III. KEY TO SHRUB VEGETATION TYPES

1a. *Abies lasiocarpa* (or occasionally *Picea engelmannii*) dominant shrub, snow avalanche path S2

1b. *Salix scouleriana* and *Alnus spp.* dominant shrubs, Jasper S6

1c. *Salix barrattiana* dominant shrub S8

1d. Various *Salix* spp., *Betula glandulosa* or *Betula pumila* dominant 2

2a. *Scirpus caespitosus* dominant herb S3

2b. *Kobresia myosuroides* dominant herb S9

2c. *Danthonia intermedia* dominant herb S11

2d. *Equisetum arvense* dominant herb S7

2e. None of the above 3

3a. *Potentilla fruticosa* usually present 4

3b. *Potentilla fruticosa* usually absent 5

4a. Bryoid cover dense, *Tomenthypnum nitens* present, *Arctostaphylos uva-ursi* usually absent, site subhygric to hydric, level to gentle slope S1

4b. Bryoid cover sparse, *Tomenthypnum nitens* absent, *Arctostaphylos uva-ursi* usually present, site mesic to subxeric, moderate to steep slope S10

5a. *Elymus innovatus* cover ≥10%, *Salix barrattiana* usually absent S12

5b. *Elymus innovatus* cover <10%, *Salix barrattiana* usually present (5-20%) S4

IV. KEY TO LOW SHRUB-HERB VEGETATION TYPES

Dominant low shrub *Potentilla fruticosa* L1

Dominant low shrubs *Juniperus communis* and *Salix glauca*, snow avalanche path L2

Dominant low shrub *Cassiope tetragona*, snowbed L4

Dominant low shrubs *Phyllodoce glanduliflora* and *Cassiope mertensiana* L5

Dominant low shrub *Juniperus horizontalis* L6

Dominant low shrub *Salix arctica* L7

V. KEY TO HERB-DWARF SHRUB VEGETATION TYPES

1a. *Dryas* spp. dominant or codominant 2

1b. *Dryas* spp. not dominant 4

2a. *Dryas drummondii* dominant H8

2b. *Dryas integrifolia* dominant, *Carex rupestris* codominant, Jasper only H15

2c. *Dryas octopetala* dominant, may contain *Dryas integrifolia* but *Carex rupestris* not codominant, see v.t. description for other differences 3

3a. *Kobresia myosuroides*, *Arctostaphylos uva-ursi* codominant H4

3b. *Salix nivalis*, *Silene acaulis* codominant H1

4a. Elevation <1700 m, subxeric to xeric grasslands 5

4b. Elevation mostly >1700 m, not subxeric to xeric grasslands 8

5a. *Agropyron* spp. dominant 6

5b. *Agropyron* spp. not dominant 7

6a. *Agropyron dasystachyum* dominant, *Artemisia frigida* codominant H7

6b. *Agropyron spicatum* usually dominant, *Elymus innovatus* often codominant H19

7a. *Koeleria cristata* dominant, *Artemisia frigida* codominant H6

7b. *Stipa richardsonii* dominant, *Koeleria cristata* codominant H13

8a. Site subhydric to hydric, very poorly drained 9

8b. Site drier and better drained 10

9a. *Eriophorum angustifolium* dominant H10

9b. *Carex aquatilis* or *Carex rostrata* dominant H11

9c. *Caltha leptosepala* and *Trollius albiflorus* codominant H9

10a. Lichens dominant, sparsely vegetated, high Alpine elevations H12

10b. Graminoids dominant 11

10c. Forbs dominant 14

11a. *Carex* spp. dominant 12

11b. *Elymus innovatus* dominant 13

12a. *Carex nigricans* dominant, Alpine snowbed H2

12b. *Carex scirpoidea* dominant, Montane-Lower Subalpine fluvial site H3

13a. *Fragaria virginiana*, *Epilobium angustifolium* abundant, site mesic H5

13b. *Koeleria cristata*, *Arctostaphylos uva-ursi* (*Hedysarum sulphurescens* in Banff) abundant, site subxeric H14

13c. *Saxifraga bronchialis* abundant, site xeric to subxeric H20

14a. Site subxeric to xeric, *Saxifraga bronchialis* and *Elymus innovatus* dominant H20

14b. Site mesic to hygric, *Saxifraga bronchialis* and *Elymus innovatus* usually absent 15

15a. *Caltha leptosepala* and *Trollius albiflorus* dominant H9

15b. *Erigeron peregrinus* and *Valeriana sitchensis* dominant H16

SUCCESSION AND CLIMAX

I.G.W. Corns and P.L. Achuff

INTRODUCTION

Although documentation of the pathways of vegetational succession was not one of the primary objectives of the Banff-Jasper Ecological Land Classification, the large amount of data collected allows the description of generalized successional trends and of seral and climax v.t.s. Succession deals with changes in vegetation over time. The time for vegetation to develop from early stages to climax ranges from more than a thousand years for the establishment of mature forest on recently deposited fluvial or morainal material (primary succession), to fewer than ten years for a mature grassland community to re-establish itself following fire (secondary succession).

The influence of fire on the vegetation of Banff and Jasper is very great, with nearly all of the present forest having been subject to fire in the past. Tande (1977) showed that the Athabasca River valley around Jasper townsite experienced major fires (>500 ha) in 24 of the years between 1665 and 1975, and that most of the present forest originated after fires in three years (1889, 1847, 1758). The potential complexity of successional relationships has been greatly simplified by the historical fire peak 100 to 120 years ago. This has resulted in the bulk of the *Pinus contorta* forests being approximately in the same successional stage. Earlier, preclimax stages are comparatively rare and are usually referable to a more common 100 to 120 years old v.t. Areas of recent burn are limited, e.g. Survey Peak - Saskatchewan Crossing and Flint's Park in Banff, lower Chaba River in Jasper.

Fire has several important roles in the environment which have been summarized by Wright and Heinselman(1973) and Tande (1977) as follows: 1) modifier of the physical-chemical environment, 2) regulator of dry matter accumulation, 3) controller of plant species composition and structure of plant communities, 4) determiner of wildlife habitat patterns and populations, 5) controller of forest insects, parasites and fungi, and 6) controller of major ecosystem processes and characteristics. Fire is unquestionably the major factor responsible for forest succession in Banff and Jasper. Fire is most influential upon the drier, lower elevation forests, shrub lands and grasslands where fuel accumulation is usually greater, trees are more closely spaced, and the climate is drier. In addition to fire, successional trends may be influenced by insects, diseases, climate, soil properties, and wildlife.

A four stage successional sequence is used in this report: early, intermediate, advanced and mature. Early successional stands are unstable, heterogeneous, often not referable to one of the v.t.s and usually less than 50 years has elapsed since stand origin after fire, flood or other major perturbation. Intermediate successional stands are moderately stable and dominated by species other than those climax for the site. Typically, they are dominated by *Pinus contorta* and show evidence of future dominance of climax species, e.g. *Picea engelmannii* and *Abies lasiocarpa* regeneration in a *Pinus contorta* forest. Successionally intermediate stands are usually 50 to 100 years old but may vary considerably from this range, since succession proceeds at different rates on different sites. Primary successions on recent floodplain or moraine, which may begin with, for example, yellow dryad-willow herb (H8) v.t. progressing through willow/horsetail (S7) v.t. and finally to stable white spruce/shrubby cinquefoil/bearberry (O3) v.t. (Fig. 23, part a), may take hundreds of years (Heusser 1956). Conversely, some stable *Picea* dominated v.t.s (e.g. white spruce/fern moss (C2) and white spruce/buffaloberry/feathermoss (C37) often show no evidence of a previous *Pinus contorta* stage and appear to pass through the intermediate stage relatively quickly. Advanced successional stands are generally 80 to 200 years old and are dominated by a mixture of seral and climax species. In forested v.t.s this is most typically a mixture of *Pinus contorta* and *Picea engelmannii* or *Abies lasiocarpa* (e.g. C11, C18, C29). The duration of this stage varies but 40 to 50 years is perhaps typical. Successionally mature (climax) v.t.s are stable, self perpetuating and the end points of plant succession. They are dominated by species best adapted to that environment and are in dynamic equilibrium with the prevailing climate and environment. Mature vegetation is the culmination of usually 150 years or more of plant succession but this time frame varies greatly as described above. The successional relationships of the v.t.s are discussed in the individual v.t. descriptions. General trends evident within the three Ecoregions are discussed below.

MONTANE ECOREGION

The Montane Ecoregion is predominantly forested and mature vegetation is characterized by *Pseudotsuga menziesii* and *Picea glauca* (e.g. Douglas fir/hairy wild rye (C1) on southerly aspects and white spruce-Douglas fir/feathermoss (C5) on northerly aspects), often successional from *Pinus contorta* dominated types such as lodgepole pine/juniper/bearberry (C3), lodgepole pine/buffaloberry/showy aster (C6), lodgepole pine/dwarf bilberry (C9) and lodgepole pine/buffaloberry/twinflower (C19) (Fig. 23, part c). Lodgepole pine/juniper/bearberry (C3) can achieve climax status on dry sites while on the driest Montane sites mature junegrass-pasture sage-wild blue flax (H6) and wheatgrass-pasture sage (H7) grassland v.t.s occur. Such grasslands may be maintained by frequent fires. On eolian landforms near the Jasper east gate and in the Saskatchewan Crossing area of Banff, *Picea* dominated white spruce/fern moss (C2), white spruce/buffaloberry/fern moss (C26), and white spruce/prickly rose/fern moss (C27) occur without any apparent distinct seral stages.

SUBALPINE ECOREGION

The Subalpine Ecoregion, also predominantly for-

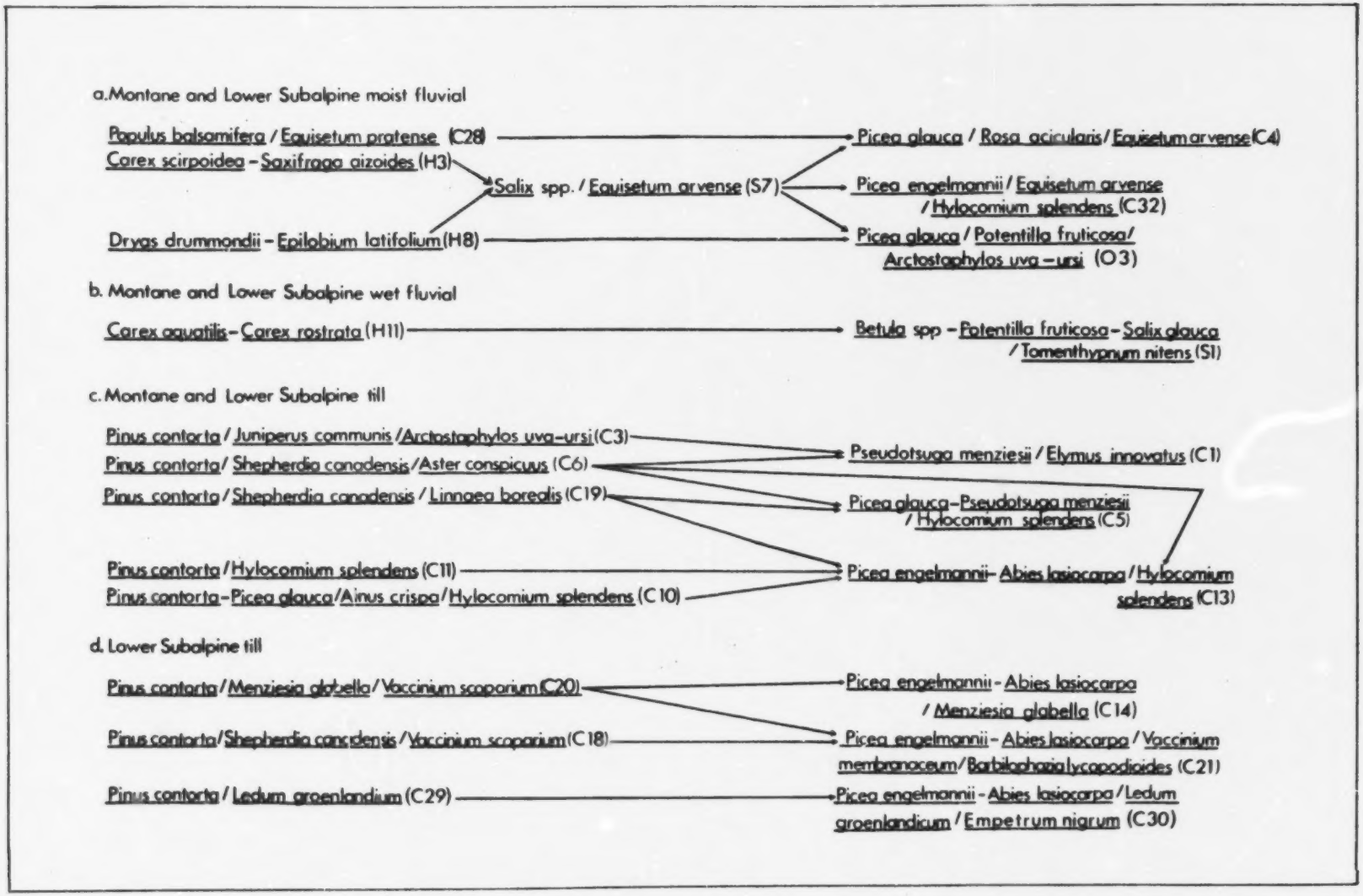

a. Montane and Lower Subalpine moist fluvial
Populus balsamifera / Equisetum pratense (C28)
Carex scirpoidea - Saxifraga aizoides (H3)
Dryas drummondii - Epilobium latifolium (H8)
Salix spp. / Equisetum arvense (S7)
Picea glauca / Rosa acicularis / Equisetum arvense (C4)
Picea engelmannii / Equisetum arvense / Hylocomium splendens (C32)
Picea glauca / Potentilla fruticosa / Arctostaphylos uva-ursi (O3)
b. Montane and Lower Subalpine wet fluvial
Carex aquatilis - Carex rostrata (H11)
Betula spp - Potentilla fruticosa - Salix glauca / Tomenthypnum nitens (S1)
c. Montane and Lower Subalpine till
Pinus contorta / Juniperus communis / Arctostaphylos uva-ursi (C3)
Pinus contorta / Shepherdia canadensis / Aster conspicuus (C6)
Pinus contorta / Shepherdia canadensis / Linnaea borealis (C19)
Pinus contorta / Hylocomium splendens (C11)
Pinus contorta - Picea glauca / Alnus crispa / Hylocomium splendens (C10)
Pseudotsuga menziesii / Elymus innovatus (C1)
Picea glauca - Pseudotsuga menziesii / Hylocomium splendens (C5)
Picea engelmannii - Abies lasiocarpa / Hylocomium splendens (C13)
d. Lower Subalpine till
Pinus contorta / Menziesia glabella / Vaccinium scoparium (C20)
Pinus contorta / Shepherdia canadensis / Vaccinium scoparium (C18)
Pinus contorta / Ledum groenlandium (C29)
Picea engelmannii - Abies lasiocarpa / Menziesia glabella (C14)
Picea engelmannii - Abies lasiocarpa / Vaccinium membranaceum / Barbilophozia lycopodioides (C21)
Picea engelmannii - Abies lasiocarpa / Ledum groenlandicum / Empetrum nigrum (C30)

Figure 23 Some plant succession trends evident in Banff and Jasper National Parks.

ested, has mature vegetation dominated by *Picea engelmannii* and *Abies lasiocarpa* (e.g. Engelmann spruce-subalpine fir/feathermoss (C13), Engelmann spruce-subalpine fir/false azalea (C14), and Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) in the lower portion of the Subalpine), often successional from *Pinus contorta* forests (e.g. lodgepole pine/buffaloberry/ twinflower (C19), lodgepole pine/false azalea/grouseberry (C20), and lodgepole pine/Labrador tea (C29) respectively; Fig. 23, part d). Successional trends are often less evident in the Upper Subalpine where the role of *Pinus contorta* as a seral species is minor. Common Upper Subalpine v.t.s (e.g. Engelmann spruce-subalpine fir/heather (O10), Engelmann spruce-subalpine fir/grouseberry (C15), and Engelmann spruce-subalpine fir/rock willow/ white mountain heather (C24) originate as *Picea-Abies* forests after fire. Succession proceeds more slowly at higher elevations often requiring 250 years or more to reach climax.

ALPINE ECOREGION AND WETLANDS

Successional processes in the Alpine Ecoregion and in Subalpine and Montane wetlands are somewhat different than in the forest. Due to the usual absence of fire, the major agents of disturbance are water erosion and, in the Alpine, cryogenic processes. Plant succession in the Alpine can be extremely slow. The present, often sparse, vegetation characteristic of this harsh environment, e.g. mountain avens-snow willow-moss campion (H1), represents development during the several thousand years since glacial retreat. Complete recovery of vegetation after trampling may take hundreds of years in some areas (Willard and Marr 1971). Distinct seral stages are less evident in Alpine areas than in Subalpine or Montane forests, and have not been recognized due to the greater difficulty of determining stand history in the Alpine v.t.s versus Subalpine forest where techniques such as increment coring may be used.

Wetland v.t.s in the Alpine, Subalpine, and Montane Ecoregions are also often characterized by slow successional processes and their characteristic herbaceous or shrubby vegetation can make stand history determination difficult. Vegetation development, often coincident with, for example, peat buildup, can be extremely slow and in the order of hundreds of years (Fig. 23, part b). For this reason most herb (H), low shrub-herb (L) and shrub (S) dominated types are usually designated as successionally mature, i.e. they are relatively stable within a 50 to 100 year time span. Geomorphological processes such as stream aggradation, erosion, cryoturbation, and peatland development cause landscape changes that are often coincident with normal vegetation successional processes, thus confounding successional history determination.

SIGNIFICANT SPECIES

P.L. Achuff and I.G.W. Corns

VASCULAR PLANTS

INTRODUCTION

During the Ecological Land Classification, four species of vascular plants new to Alberta were collected: *Hippuris montana* Ledeb., *Sedum divergens* Watson, *Tsuga heterophylla* (Raf.) Sarg., *Vaccinium ovalifolium* J.E. Smith. In addition, 148 species have been classified as rare and thus, are deserving of special management consideration. Other species have been identified as of interest because they are nearly rare or have a geographic range boundary within Banff and Jasper. This section provides information on species in all three categories.

Specimens are deposited in one or more of the following herbaria: CAFB (Northern Forest Research Centre, Edmonton), ALTA (University of Alberta), CAN (National Museum, Ottawa), DAO (Central Experimental Farm, Ottawa), NY (New York Botanical Garden, Bronx). Collector's names are abbreviated as follows: DK (D. Karasiuk), IC (I. Corns), JC (J. Cuddeford), JD (J. Dyck) , JE and JEM (J. Marsh), LC (L. Cole), PA and PLA (P. Achuff), SJ (S. Scott). Figure 24 shows the location of features cited below which are not on National Topographic Survey maps.

NEW TO ALBERTA

Hippuris montana Ledeb.: *Range* - Alaska, Yukon, Northwest Territories, British Columbia, western Alberta, Washington. *Alberta* - (Fig. 25) Jasper National Park: Catacombs Mt. (IC misc. 28 Sep 76), Divergence Creek (IC misc. 20 Sep. 77), Upper Lick Creek (IC misc. 19 Aug 77), Miette Pass (IC misc. 29 Jul 79). *Habitat* - shallow stream margins, wet mossy depressions, Alpine.

Sedum divergens Watson: *Range* - Cascade and Olympic Mountains of Washington, British Columbia, extreme southeastern Alaska, Klamath Mountains of Oregon. *Alberta* - (Fig. 26) Jasper National Park: Derr Creek (IC9141), Upright Pass (IC misc. 25 Jul 79), Corral Creek (JE misc. 10 Sep 79), Miette Pass (IC misc. 29 Jul 79), Mt. Thornton (PLA3651), Mt. Ranee (PLA3682), Mt. Bridgland (IC misc. 9 Sep 77). *Habitat* -

Figure 24 Location of features not on the National Topographic Series maps.

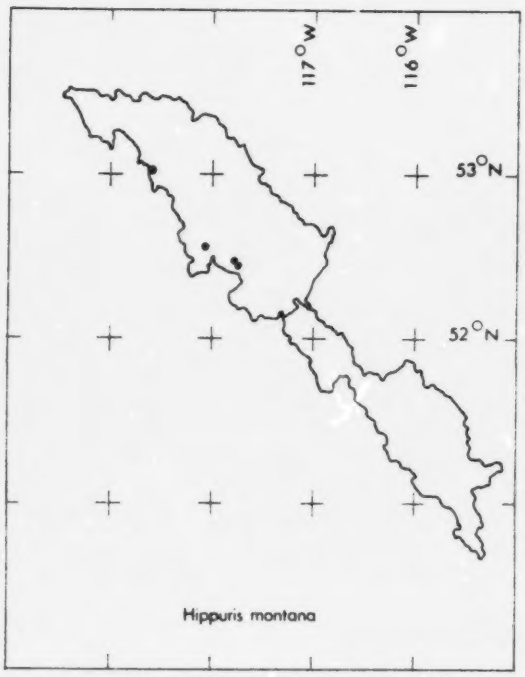


Figure 25 Distribution of *Hippuris montana* in Banff and Jasper.

Figure 27 Distribution of *Tsuga heterophylla* in Banff and Jasper.

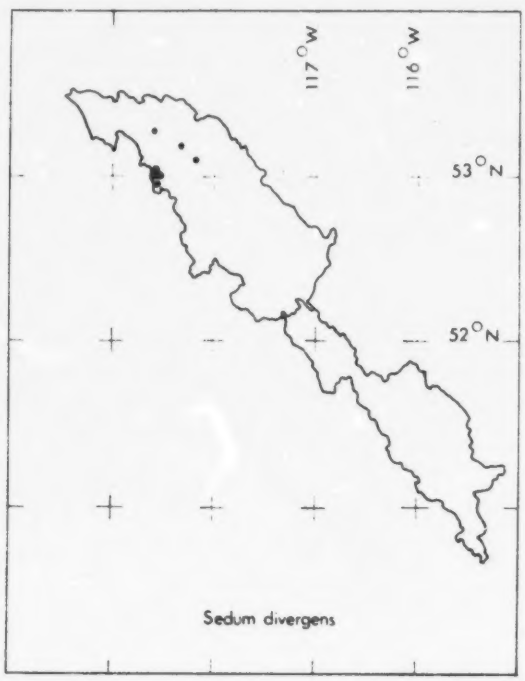


Figure 26 Distribution of *Sedum divergens* in Banff and Jasper.

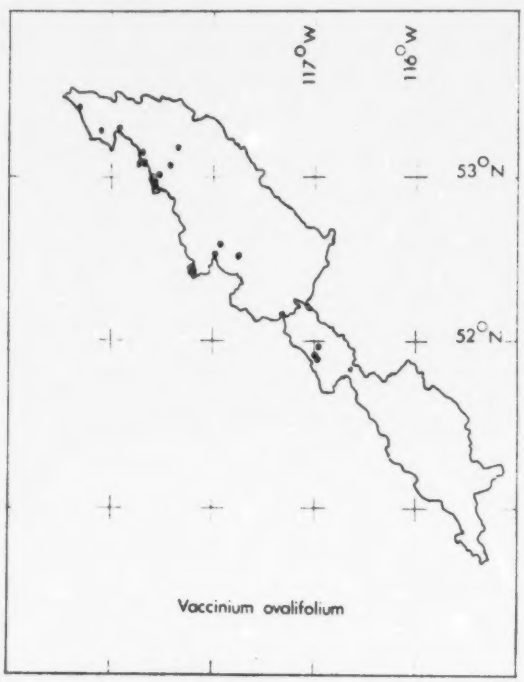


Figure 28 Distribution of *Vaccinium ovalifolium* in Banff and Jasper.

rocky slopes and ledges, avalanche slopes, Lower and Upper Subalpine.

Tsuga heterophylla (Raf.) Sarg.: *Range* - southern Alaska to California, interior British

Columbia from 55° to northwestern Montana, western Alberta. *Alberta* - (Fig. 27) Banff National Park: Coleman Creek (PLA misc. 7 Jun 77), Alexandra River (JD misc. 8 Aug 77), Castleguard River (DK misc. Jun 76), Jasper National Park: Fryatt Creek (IC misc. 17 Aug 77), Whirlpool River (SJ misc. 20 Sep 78). *Habitat* - moist *Picea engelmannii-Abies lasiocarpa* forests, Lower Subalpine.

Vaccinium ovalifolium J.E. Smith: *Range* - Alaska, British Columbia, western Alberta, Washington, Oregon, Idaho, western Montana, isolated areas in Ontario, Michigan, Quebec, Nova Scotia, Labrador and Newfoundland, also eastern Asia. *Alberta* - (Fig. 28) Banff National Park: Arctomys Creek (PA7069), Glacier Lake (PA7094), Southeast Lyell Glacier (PLA misc. 4 Aug 77), Chephren Lake (IC 7045). Jasper National Park: Canoe Pass (JC misc. 9 Aug 77), Snake Indian River - Hoodoo Cabin (JE9103.1), Geraldine Lakes (PLA3724), Mt. Beaupre (IC misc. 29 Jul 79), Mt. Knight (IC9080), Short Creek (IC9098), Upright Pass (IC9122), Mt. Thornton (PLA3694), Swoda Mtn. (LC misc. 23 Jul 79), upper Miette River (IC7080), Miette River (IC misc. 13 Aug 79), Lick Creek (IC misc. 19 Aug 77), Divergence Creek (IC 20 Sep 77). *Habitat* - moist *Picea engelmannii-Abies lasiocarpa* forests, Lower Subalpine.

All four of these species have small populations of limited range in the parks and are rare as defined below.

RARE SPECIES

In compiling a list of rare species, two recent works on rare plants in Alberta by Argus and White (1978) and Packer and Bradley (1978) have been consulted. Argus and White (1978) define a rare plant as "one that has a small population in the province...restricted to a small geographical area (usually less than 3900 sq.km.) or it may occur sparsely over a wide area." Packer and Bradley (1978) consider a rare species to be known from $\leq$10 localities. In Banff and Jasper, a rare plant is considered to occur within a restricted geographic area, usually $<$500 sq.km., and at usually $<$10 collection sites; also, the plant is often at the edge of its geographic range. All three criteria usually indicate a small population in the parks. With a few exceptions, plants considered rare in the province are also considered rare in Banff and Jasper.

In the list below, B indicates occurrence in Banff and J occurrence in Jasper. The comments with each species indicate its range and habitat in the parks as presently known. Information for species on the list which were not seen during the inventory is derived largely from Argus and White (1978) and Packer and Bradley (1978).

Agroelymus xmossii Lepage: B, Lake Louise area, pine forests, Lower Subalpine, a hybrid of *Agropyron trachycaulum* and *Elymus canadensis*.

Agropyron violaceum (Hornem.) Lange spp. *andinum* (Scribn. & Sm.) Meld.: B, Sunwapta Pass, moist meadows, Upper Subalpine.

Agrostis borealis Hartm.: B, Paradise Valley, J, Mt. Edith Cavell, moist meadows, Upper Subalpine.

Agrostis humilis Vasey: B, Healy Ck., Lost Horse Ck., Sunshine, J, Marble Mtn., meadow, Upper Subalpine.

Agrostis thurberiana Hitch.: B, Simpson Pass, J, Centre Pass, Mt. Pattison, moist meadow, Lower and Upper Subalpine.

Antennaria acuta Rydb.: B.

Antennaria alpina (L.) Gaertn. var. *media* (Greene) Jeps.: B, Glacier L., Molar Pass, Goat Ck., J, Chaba River, Whirlpool River, meadow and tundra, Upper Subalpine and Alpine.

Antennaria angustata Greene: B, Cyclone cabin, J, Mt. Edith Cavell, Derr Ck., Smoky cabin, meadow, Upper Subalpine and Alpine.

Antennaria corymbosa E. Nels.: B, Sunshine, Clearwater R., J, Brazeau R., Lower and Upper Subalpine.

Antennaria luzuloides T. & G.: J.

Antennaria monocephala DC: B, Dolomite Ck., J, Rocky R., Mt. Ranee, tundra, Alpine.

Aquilegia jonesii Parry: J, east gate, Montane.

Arenaria humifusa Wahl.: B,J.

Arenaria nuttallii Pax: J, Corral Ck., Pyramid Mtn., dry ridges, Alpine.

Arnica alpina (L.) Olin ssp. *angustifolia* (M. Vahl) Maguire: B,J, meadows, Upper Subalpine and Alpine.

Arnica longifolia D.C. Eaton: B,J.

Arnica parryi Gray: B, Helen Ck. trail, J, Portal Ck., spruce-fir forest, Lower Subalpine.

Artemisia borealis Pall.: J, dry slopes, Upper Subalpine and Alpine.

Aster maccallae Rydb.: B,J, streamsides, Lower Subalpine

Athyrium alpestre (Hoppe) Rylands: J, rocky slopes, Upper Subalpine and Alpine.

Botrychium boreale (Fries) Milde: B, Siffleur R., Sentinel Pass, moist meadows, Upper Subalpine.

Botrychium lanceolatum (Gmel.) Angstr.: B, Mt. Temple, J, Colonel Pass, moist meadows, Upper Subalpine.

Braya purpurascens (R.Br.) Bunge: J, rocky slopes, Alpine.

Bromus purgans L.: B, moist forest, Lower Subalpine.

Carex athabascensis Hermann: J, Calumet Ck., moist meadow, Lower Subalpine.

Carex bigelowii Torr.: B, dry slopes, Alpine.

Carex bipartita Allioni: B, Ptarmigan L., Divide Ck., meadow, Upper Subalpine and Alpine.

Carex crawei Dewey: B,J, wet meadow, Upper Subalpine and Alpine.

Carex eleusinoides Turcz.: J, Mt. Edith Cavell, wet meadow, Upper Subalpine and Alpine.

Carex glacialis Mack.: B, Mt. Brewster, dry meadow, Upper Subalpine and Alpine.

Carex illota Bailey: B, Simpson Pass, J, Geraldine L. trail, wet meadow, Upper Subalpine and Alpine.

Carex interior Bailey: B, Rockbound L. trail, Saskatchewan Crossing, J, Warden Office, streamsides, Montane to Upper Subalpine.

Carex lenticularis Michx.: J, Smoky cabin, sedge fen, Lower Subalpine.

Carex limnophila Hermann: B, J, moist meadow, Lower and Upper Subalpine.

Carex loliacea L.: J, Portal Ck., Jasper townsite, moist woods, Montane to Upper Subalpine.

Carex mertensii Prescott: J, Geraldine Lookout road, moist forest, Lower and Upper Subalpine.

Carex misandra R.Br.: J, tundra, Alpine.

Carex petricosa Dewey: B, Sunwapta Pass, J, Beaver Lake, Colonel Pass, Mt. Edith Cavell, Medicine Tent R., rocky outcrops and meadows, Upper Subalpine and Alpine.

Carex supina Willd. ssp. *spaniocarpa* (Steud.) Hult.: B, Sunshine, meadow, Upper Subalpine.

Carex vesicaria L.: B, wet meadow, Upper Subalpine and Alpine.

Castilleja hispida Benth.. B, Mt. Norquay, pine forest, Lower Subalpine.

Clintonia uniflora (Schult.) Kunth: J, Smoky cabin, moist forest, Lower Subalpine.

Corispermum hyssopifolium L.: J, Talbot L., sand dune, Montane.

Crepis atrabarba Heller: B, dry grasslands, Montane and Lower Subalpine.

Crepis intermedia A. Gray: B, Cory Pass trail, dry grassland, Montane.

Cryptantha affinis (Gray) Greene: B, grassy slopes, Lower Subalpine.

Cypripedium montanum Dougl.: J, Banff-Jasper Hwy., moist forest, Lower Subalpine.

Cystopteris montana (Lam.) Bernh. J, Canoe Pass, moist forest, Lower Subalpine.

Draba albertina Greene: B, Sawback L., Rockbound L., J, Pyramid Mtn., meadow, Upper Subalpine and Alpine.

Draba densifolia Nutt.: B, talus slopes, Upper Subalpine.

Draba fladnizensis Wulf.: B, Divide Ck., J, tundra, Alpine.

Draba glabella Pursh: J, Columbia Icefields, Signal Mtn., Upper Subalpine and Alpine.

Draba kananaskis Mulligan: J, Maligne Lk., open forest, Lower and Upper Subalpine.

Draba longipes Raup: J, Sassanach Mtn., Medicine Tent R., Portal Ck., meadow, Upper Subalpine and Alpine.

Draba reptans Lam.: B, Cory Pass trail, dry grassland, Lower Subalpine.

Draba ventosa Gray: J, Opal Hills, rocky outcrop, Alpine.

Drosera anglica Huds.: Fryatt Ck., wet shrub meadow, Lower Subalpine.

Drosera linearis Goldie: B, sedge fen, Lower Subalpine.

Dryopteris assimilis S. Wats.,: B, Forbes Ck., Mt. Eisenhower, J, Quincy Ck., Pyramid L., Portal Ck., Moab L., Lynx Ck., Miette L., Lick Ck., moist forest, Lower and Upper Subalpine.

Dryopteris fragrans (L.) Schott.: J, Maligne L., Geraldine L. trail, Lower Subalpine.

Epilobium luteum Pursh: B, J, Lynx Ck., Lower Subalpine.

Erigeron flagellaris Gray: J, Mina L., Montane.

Erigeron ochroleucus Nutt.: B, Saskatchewan Crossing, Indianhead Ck., J, Talbot L., dry meadow, Montane to Lower Subalpine.

Erigeron pallens Cronq.: B, Eagle Mtn., Quartz Ridge, J, Wall Pass, talus, Upper Subalpine and Alpine.

Erigeron scotteri Boiv.: B, J, Alpine.

Eriophorum callitrix Cham.: B, Snow Creek Pass, J, Whistler's Mtn., cottongrass fen, Alpine.

Erysimum pallasii (Pursh) Fern.: B, Sunset Pass, Whitehorn Mtn., J, Resthaven Icefield, Wilcox Pass, Mt. Simla, Mt. Oliver, Bald Hills, talus and tundra, Alpine.

Festuca subulata Trin.: B, Molar Mtn., grassland, Upper Subalpine.

Festuca viridula Vasey: J, grassland.

Galium palustre L.: J, moist meadow.

Gaultheria humifusa (Grah.) Rydb.: B, Glacier L., Bow Pass, J, Blue Creek, Mt. Davidson, Mt. Catacombs, Windy Castle, Knight Ck., Divergence Ck., Miette Pass, Trapper Ck., Resthaven Icefield, Amethyst L., moist forest, Upper Subalpine.

Gentiana glauca Pallas: B, Dolomite Pass, Redoubt L., J, Maligne R., Marble Mtn., Marmot Mtn., Pyramid Mtn., Signal Mtn., meadow, Upper Subalpine and Alpine.

Geranium erianthum DC.: J, dry grassland, Montane.

Habernaria unalascensis (Spreng.) S. Wats.: B, J.

Haplopappus uniflorus (Hook.) T. & G.: B, Saskatchewan Crossing, J, Willow Ck., wet meadow, Montane and Lower Subalpine.

Heuchera glabra Willd.: J, Whirlpool R., Moab L., Mt. Edith Cavell, Lower Subalpine.

Hieracium albertinum Farr.: B, Healy Ck., Paradise Valley, Upper Subalpine.

Hierochloe alpina (Sw.) R. and S.: J, Marmot Basin, Signal Mtn., Mt. Edith Cavell, Pyramid Mtn., Mt. Kerr,

Azure L., Swoda Ck., meadows and tundra, Upper Subalpine and Alpine.

Isoetes muricata Dur.: J, lake shore, Lower Subalpine.

Juncus biglumis L.: B, J, Mt. Edith Cavell, wet meadow and tundra, Upper Subalpine and Alpine.

Juncus parryi Engelm.: B, Flint's Park turn-off, Lower Subalpine.

Juncus stygius L. var. *americanus* (Buch)Hult.: B, Lake Louise, fen, Lower Subalpine.

Koenigia islandica L.: J, Mt. Edith Cavell, Whistler's Mtn., wet meadow, Upper Subalpine.

Lesquerella arctica (Wormsk.)S. Wats.: B.

Listera caurina Piper: B, Lake Louise, J, Roche De Smet, pine forest, Lower Subalpine.

Lithophragma glabrum Nutt.: B.

Lithophragma parviflora (Hook.) Nutt.: B, dry grassland, Montane.

Loiseleuria procumbens (L.)Desv.: J, Outpost L., Topaz L., Linda L., Azure L., Blue Ck., Mt. Edith Cavell, Resthaven Icefield, rocky outcrops, Upper Subalpine.

Lupinus nootkatensis Donn: J, Byng cabin, Twintree L., Miette R., Mt. Simla, Tonquin Valley, Snaring R., Canoe Pass, Resthaven Icefield, moist meadow, Upper Subalpine.

Luzula arcuata (Wahl.) Sw.: B, Ptarmigan L., J, Linda L., Calumet Ridge, Bald Hills, Pyramid Mtn., Mt. Edith Cavell, tundra, Alpine.

Lycopodium sitchense Rupr.: B, Fish L., J, Upright Pass, Blue Ck., Lick Ck., Snake Indian Mtn., Catacombs Mtn., Divergence Ck., Smoky cabin, moist meadow, Upper Subalpine and Alpine.

Melica spectabilis Scribn.: B, Sunshine, meadow, Upper Subalpine.

Mimulus lewisii Pursh: J, Snaring R., Lower Subalpine.

Mitella breweri A. Gray: B, Marvel Pass, Sunshine, moist forest, Upper Subalpine.

Osmorhiza chilensis Hook. & Arn.: B, Mt. Murchison, Mt. Eisenhower, J, Mt. Christie, moist forest, Lower and Upper Subalpine.

Osmorhiza purpurea (Coult. & Rose) Suksd.: J, Ranee Mtn., moist forest, Lower Subalpine.

Panicum occidentale Scribn.: B, wet meadow, Montane.

Papaver freedmanianum D. Love: J, Opal Hills, Alpine.

Papaver kluanensis D. Love: B, Siffleur R., Gibbon Pass, Divide Ck., J, Mt. Simla, Mt. Tekarra, Smoky cabin, tundra and talus, Alpine.

Pedicularis arctica R.Br.: B, Indianhead Ck., Carrot Ck. Pass, Peters Ck., J, Pyramid Mtn., Mt. Edith Cavell, Signal Mtn., Jonas Ck., Snowbowl, Marble Mtn., tundra, Alpine.

Pedicularis contorta Benth.: B, Whitehorn Mtn., Stony Ck., Healy Ck., Molar Mtn., Spray R., Sentinel Pass, tundra, Alpine.

Pedicularis flammea L.: B, Douglas L., Panther Mtn., Dormer Pass, Divide Ck., Fortymile Ck., J, Cairn Pass, Rocky Forks, Whitehorse cabin, Restless R., Wilcox Pass, tundra, Alpine.

Pedicularis lanata Cham. & Schlect.: J, Vine Creek, Little Heaven cabin, Mt. Stornaway, Blue Ck., Rocky R., Whitehorse cabin, open forest and tundra, Upper Subalpine and Alpine.

Pedicularis racemosa Dougl.: B, Marvel L., J, Maligne L., Palisades Lookout, meadow, Upper Subalpine.

Pellaea atropurpurea (L.)Link: B, Tunnel Mtn., calcareous cliffs, Montane.

Pellaea glabella Mett. var. *occidentalis* (E. Nels.) Butters: B, Tunnel Mtn., Mt. Rundle, Sawback Range, J, Jasper townsite, cliffs, Montane.

Penstemon fruticosus (Pursh) Greene var. *scouleri* (Lindl.)Cronq.: B, Douglas L., Spray R., Marvel L., J, Waterfalls cabin, Verdant Pass, Portal Creek, rocky slopes, Lower and Upper Subalpine.

Phyllodoce intermedia (Hook.)Camp: B, Molar Pass, Dolomite Pass, J, Brazeau R., meadow, Upper Subalpine and Alpine.

Plantago canescens Adams: J, Pyramid L., Montane.

Poa lanata Scribn. & Mer.: B.

Poa lettermanii Vasey: B,J, Whistler's Mtn., meadow, Upper Subalpine and Alpine.

Poa stenantha Trin.: B, Lake Agnes, Whitehorn Mtn., open forest, Upper Subalpine.

Primula egaliksensis Wormsk.: J, Pyramid L., Kidney L., moist meadow, Montane and Lower Subalpine.

Primula stricta Hornem.: J, Roche De Smet, Willow Ck., wet meadow, Lower Subalpine.

Pteridium aquilinum (L.)Kuhn: B,J, Short Ck., moist forest, Lower Subalpine.

Ranunculus gelidus Karel. & Kiril.: B, Hillsdale, Lower Subalpine.

Ranunculus nivalis L.: J, Signal Mtn., Mt. Stornoway, meadow, Alpine.

Ranunculus occidentalis Nutt. var. *brevistylis* Greene: J, Swoda Ck., Caribou Lks., Chetang Ridge, Moose Pass, Adolphus L., Linda L., Mowich Ck., Mt. Beaupre, Miette Pass, Upright Pass, Whistler's Mtn., moist meadow, Alpine.

Ranunculus verecundus Robins.: B, Bryant Ck., Ptarmigan L., J, Rocky R., meadow, Upper Subalpine.

Rhododendron lapponicum (L.)Wahlenb.: J, Southesk R., open forest, Lower and Upper Subalpine.

Ribes laxiflorum Pursh.: B, Chephren L., J, Roche De Smet, upper Athabasca R., Geraldine Lks. trail, moist forest,

Lower Subalpine.

Rorippa obtusa (Nutt.)Britt.: B, Owl L., lakeshore, Lower Subalpine.

Rubus chamaemorus L.: J, Smoky cabin, wet forest, Lower Subalpine.

Salix alaxensis (Anderss.)Cov.: J, Wall Pass, Tie Camp, shrubby meadow, Lower and Upper Subalpine.

Salix lanata L. ssp. *calcicola* (Fern. & Weig.)Hulten: B, Malloch Ck., Saskatchewan Crossing, J, Whirlpool R., meadow, Lower Subalpine.

Salix novae-angliae Anderss.: B, Saskatchewan Crossing, floodplain, Lower Subalpine.

Salix reticulata L. ssp. *reticulata*: J, Southesk L., Restless R., Waterfalls Cabin, streamside, Lower Subalpine.

Salix sitchensis Sans.: J, Athabasca R., riverbank, Lower Subalpine.

Salix stolonifera Cov.: J, Opal Hills, meadow, Alpine.

Saxifraga arguta D. Don: J, Lynx CK., Colonel Pass, Portal Ck., Meadow, Upper Subalpine.

Saxifraga debilis Engelm.: B, Clearwater Pass, Lost Horse Ck., J, Calumet Ridge, Topaz L., seepy cliffs, Upper Subalpine and Alpine.

Saxifraga flagellaris Willd.: B, Indianhead Ck., J, Roche De Smet, tundra, Alpine.

Saxifraga nivalis L.: B, Sentinel Pass, Sunset Pass, J, Wilcox Pass, Signal Mtn., meadow, Upper Subalpine and Alpine.

Saxifraga punctata L.: B,J, Mt. Edith Cavell, Mt. Simla, Mt. Thornton, meadow, Upper Subalpine.

Scirpus hudsonianus (Michx.)Fern.: J, Smoky cabin, sedge fen, Lower Subalpine.

Silene furcata Raf. (=*Lychnis affinis* J. Vahl):B.

Smilacina trifolia (L.)Desf.: J, Miette Hot Springs Rd., Celestine Rd., wet forest, Montane and Lower Subalpine.

Sorbus sitchensis Roemer: B, Lake Louise, J, Blue Ck., Lynx Ck., moist forest, Lower and Upper Subalpine.

Sparganium hyperboreum Laest.: B, Simpson Pass, J, Tonquin Valley, Lower Subalpine.

Stellaria americana Porter: J, Jonas Pass., Alpine.

Stellaria umbellata Turcz: B, Taylor L., meadow, Upper Subalpine.

Telesonix jamesii Rydb.: J, Restless R., Cinquefoil Mtn., Lower Subalpine.

Thelypteris phegopteris (L.) Slossen: J, moist forest. Lower Subalpine .

Thuja plicata D. Don: B, Glacier L., Survey Pk., Castleguard R., Lower Subalpine.

Tofieldia coccinea Tich J, Athabasca R., Montane.

Veronica salina Schur: B, Cascade Power House, stream edge, Montane.

Viola selkirkii Pursh: J, Mt. Edith Cavell, moist forest,Lower Subalpine.

Woodsia glabella R.Br.: B,J, moist cliffs, Lower Subalpine.

OTHER SPECIES

These species include those which are special because they are nearly rare or they have a geographic range boundary in the parks. The comments with each species indicate the special interest.

Arnica louiseana Farr: nearly rare.

Artemisia norvegica Fries: southern range boundary in northern Banff.

Berberis repens Lindl.: northern range boundary in southern Banff.

Campanula uniflora L.: nearly rare.

Castilleja raupii Pennell: southern range boundary in central Jasper.

Castilleja rhexifolia Rydb.: northern range boundary in central Jasper.

Chimaphila umbellata (L.) Bart.: nearly rare.

Claytonia megarrhiza (A. Gray) Parry: northeastern range boundary in northern and eastern Banff.

Draba macounii O.E. Schulz: nearly rare.

Dryas integrifolia Vahl: nearly rare.

Erythronium grandiflorum Pursh.: range extension to northern Jasper.

Festuca idahoensis Elmer: nearly rare. northern range boundary in southern Banff.

Hedysarum sulphurescens Rydb.: northern range boundary in northern Banff.

Juniperus scopulorum Sarg: northern range boundary in southern Banff.

Larix laricina (DuRoi) K. Koch: western range boundary in central Jasper.

Larix lyallii Parl.: northern range boundary in central Banff.

Ledum glandulosum Nutt.: range boundary in southern Banff.

Mitella trifida Graham: nearly rare.

Muhlenbergia richardsonis (Trin.) Rydb.: nearly rare.

Picea mariana (Mill.) BSP: southern range boundary in northern Banff.

Pinus flexilis James: northern range boundary in northern Banff.

Potentilla glandulosa Lindl.: nearly rare.

Sedum roseum (L.) Scop.: northern range boundary in central Banff.

Stipa comata Trin. and Rupr.: nearly rare.

Thermopsis rhombifolia (Nutt.) Richards: nearly rare.

Vaccinium myrtilloides Michx.: nearly rare.

Vaccinium scoparium Leiberg: northern range boundary in northern Jasper.

Vaccinium uliginosum L.: nearly rare.

NONVASCULAR PLANTS

INTRODUCTION

The selection of rare liverworts and mosses is based primarily on information provided by

Dr. D.H. Vitt, Department of Botany, University of Alberta. The lichen information was supplied by J. Marsh, Alberta Institute of Pedology. The status "rare" is based on an abundance scale (dominant, common, infrequent, uncommon, rare) reflecting the quantity of the taxon in Banff and Jasper; its abundance may be quite different in other parts of its range. This approach differs from that used for the vascular plants because the ranges and abundances of nonvascular plants are much less well known. B or J means collected only in Banff or Jasper; taxa with neither occur in both parks.

LIVERWORTS: RARE SPECIES

Anthelia julacea (L.)Dum., J.
Asterella ludwigii (Schwaegr.) Underw., J.
Athalamia hyalina (Sommert.) Hatt., B.
Calypogeja integristipula Steph., J.
Calypogeja neesiana (Mass. & Carest.) K. Muell., J.
Calypogeja suecica (H. Arnell & J. Perss.) K. Muell., J.
Geocalyx graveolens (Schrad.) Nees, J.
Gymnomitrion concinnatum (Lightf.) Corda, J.
Harpanthus flotovianus (Nees) Nees, J.
Lophozia rutheana (Limpr.) M.A. Howe, J.
Marsupella sphacelata (Gieseke) Dum., J.
Radula complanata (L.) Dum., J.
Scapania undulata (L.) Dum., J.

MOSSES: RARE SPECIES

Amblystegium varium (Hedw.) Lindb.
Aulacomnium turgidum (Wahlenb.) Schwaegr., J.

Blindia acuta (Hedw.) B.S.G., B.
Brachythecium collinum (Schleich. *ex.* C. Muell.) B.S.G.
Brachythecium leibergii Grout, B.
Calliergon sarmentosum (Wahlenb.) Kindb., J.

Calliergon stramineum (Brid.) Kindb., J.
Campylium radicale (P.-Beav.) Grout, J.
Conostomum tetragonum (Hedw.) Lindb., J.
Desmatodon obtusifolius (Schwaegr.) Schimp., J.

Desmatodon systylius Schimp., J.
Dicranum brevifolium Kindb. var. *bistratosum* Peters.
Dicranum flagellare Hedw.
Didymodon johansenii (Williams) Crum, J.
Distichium inclinatum (Hedw.) B.S.G.
Encalypta brevipes Schljak., B.
Encalypta brevicolla (B.S.G.) Bruch. *ex* Angstr.
Encalypta mutica Hagen, B.
Encalypta spathulata C. Muell., B.
Fissidens osmundoides Hedw.
Grimmia torquata Hornsch. *ex* Grev., J.
Homalothecium aeneum (Mitt.) Lawt., J.
Hygrohypnum bestii (Ren. & Bryhn *ex* Ren.) Holz. *ex* Broth., J.
Hylocomium pyrenaicum (Spruce) Lindb., J.
Hypnum bambergeri Schimp.
Hypnum recurvatum B.
Isopterygium pulchellum (Hedw.) Jaegr. & Sauerb.
Oncophorus virens (Hedw.) Brid.
Orthotrichum pallens Bruch. *ex* Brid.
Paraleucobryum longifolium (Hedw.) Loeske.
Platydictya jungermannioides (Brid.) Crum.
Pogonatum urnigerum (Hedw.) P.-Beauv., J.
Polytrichum sexangulare Brid., J.
Rhacomitrium fasciculare (Hedw.) Brid., J.
Rhacomitrium heterostichum (Hedw.) Brid, J.

Rhacomitrium heterostichum (Hedw.) Brid var. *sudeticum* (Funck) Dix *ex* Bauer
Rhytidiadelphus squarrosus (Hedw.) Warnst., J.

Rhytidiopsis robusta (Hedw.) Broth.
Roellia roellii (Broth. *ex* Roell.) Andr. *ex* Crum
Saelania glaucescens (Hedw.) Bomanss. & Broth.
Scorpidium turgescens (T. Jens.) Loeske
Sphagnum russowii Warnst., J.
Timmia megapolitana Hedw.
Tortella inclinata (R. Hedw.) Limpr.

LICHENS

New to Alberta

Caloplaca epithallina Lynge: *Range - New Mexico, Colorado, South Dakota, Greenland. Alberta:* Banff National Park: Horseshoe L. (JE8066.1), Jasper National Park: Fiddle River (JE9020).
Habitat: calcareous rock, dry grassland, Upper Subalpine.
Thelidium decipiens (Nyl.) Kremp.: *Range* - Circumpolar, arctic-alpine,
Alberta - Banff National Park: Rockbound Lake (JEM655).

Rare

Arthropyrenia punctiformis (Pers.) Mass., J.
Arthroraphis citrinella (Ach.) Poelt, J.
Caloplaca cladodes (Tuck.) Zahlbr., J.
Catillaria chalybeia (Borr.) Mass., J.
Cetraria canadensis (Ras.) Ras.
Cladonia clavulifera Vain., B.
Cladonia subcervicornis (Vain.) Kernst., B.
Cyphelium inquinans (Sm.) Trev., B.
Cyphelium pinicola L. Tibell.
Dermatocarpon cinereum (Pers.) Th.Fr., J.
Dermatocarpon vagans Imsh., B.
Glypholecia scabra (Pers.) Muell. Arg., J.
Ionaspis ochracella (Nyl.) Magn., J.
Lasallia pensylvanica (Hoffm.) Llano, J.
Lepraria chlorina (Ach.) Ach. *ex* Sm., B.
Letharia columbiana (Nutt.) Thomps., J.
Lobaria oregana (Tuck) Muell. Arg.
Nephroma helveticum Ach., J.
Pannaria microphylla (Sw.) Mass., B.
Physcia constipata (Nyl.) Norrl. & Nyl., B.
Polyblastia sendtneri Kremp., J.
Ramalina thrausta (Ach.) Nyl., J.

Rinodina bischoffii (Hepp) Mass., J.
Rinodina polyspora Th.Fr., J.
Solorinella asteriscus Anzi, J.

Thelidium decipiens (Nyl.) Kremp., B.
Varicellaria rhodocarpa (Koerb.) Th.Fr.
Xylographa vitiligo (Ach.) Laund., J.

CHAPTER IV

ECOLOGICAL INTEGRATION OF LANDFORMS, SOILS, AND VEGETATION

PHILOSOPHICAL PRINCIPLES GOVERNING THE DEVELOPMENT OF THE ECOLOGICAL METHODOLOGY .... G.M. Coen, B.D. Walker, and W.S. Taylor

MAPPING METHODOLOGY .....B.D. Walker, I.G.W. Corns, W.S. Taylor, and G.M. Coen

ECOSITE DESCRIPTIONS .....B.D. Walker, W.S. Taylor, D.T. Allan, and R.E. Wells

PHILOSOPHICAL PRINCIPLES GOVERNING THE DEVELOPMENT OF THE ECOLOGICAL METHODOLOGY

G. M. Coen, B. D. Walker, and W. S. Taylor

INTRODUCTION

In the late 1960's during public hearings on Park's master plans, Park authorities supported conservation groups recommendations that adequate base level data on natural resources were prerequisite for responsible planning and management of Canada's National Parks (East et al. 1979). A pilot project in Waterton Lakes National Park collected and presented resource information (soils, geology, forest cover, habitat type, wildlife species distribution, archeological sites) as independent reports on each resource sector. The resource data were gathered at differing mapping intensities and scales with the result that data integration by the planning teams became complex and difficult. To simplify the use of resource inventory data for planning, consideration was given to an integrated (biophysical) approach to resource inventory (Lacate 1969). Thus, when separate contracts were let for the vegetation and physical resource sectors in Yoho National Park, the research teams were also requested to compile a biophysical map after the field work was completed. When the two teams began to combine the soils and vegetation data into a biophysical map it was apparent that slight modification of original mapping concepts would have produced a map with more consistent repeating ecological map concepts. The fact that both teams used essentially closed legends facilitated the merger of the two data bases and assisted in the development of biophysical map concepts which would have otherwise been much less apparent (closed and open legends are discussed in the next section).

These experiences reinforced the developing ideas that not only should all resource sectors be linked to one set of polygons but also that the map legend should define holistic, repeating ecological map unit concepts. A pilot project was undertaken in the Lake Louise area in 1974 (Holland 1976, Walker et al. 1978) to develop and test a land classification methodology appropriate to the needs of the Mountain National Parks. The following discussion is background for the methodology used to map Banff and Jasper National Parks.

UNDERLYING PRINCIPLES

Three important guidelines were used in developing the ecological mapping procedures for Banff and Jasper.

1. The map, legend and report shou'd be easily interpretable to assist in management decisions;
2. The map unit concept (Ecosite in this case) should be repetative and holistic so that information obtained about land use response in a familiar area can be transferred to a similar but unfamiliar area;
3. Mapped information should be of uniform intensity and reliability throughout.

With reference to the first guideline, the map, legend and report should be easily interpretable to assist in management decisions. The design of the legend and map symbols can greatly facilitate interpretations (Coen 1973).

Maps made with multifactor, open legends resulting in symbols like $\frac{3\,MOB\text{-}SHP2}{3A:4A}$ 2mfT and (Fig.8 in Gimbarzevsky 1976) are difficult to interpret (read and remember) for specific land uses. The symbol denotes a hill, 2 indicates a well drained site, mf indicates moderately fine texture and T indicates a till deposit. The first 3 indicates accompanying vegetation 21 to 40 feet high, maple-oak-birch species group and spruce to hemlock-pine species group, the second 3 signifies 51 to 75% crown closure, while the denominator signifies a young to mature stand, retarded growth with forest cover affected by exposure and shallow soils. Because symbols denoting the various map unit components are allowed to vary at random, the number of combinations, each giving new map units, is very large. Each of these map units must be evalutated before a land use decision can be made.

A semi-closed legend and simpler map symbol were chosen as the more desirable alternative for the Banff-Jasper Ecological Land Classification. Slope and selected landscape modifying processes were allowed to vary independently of the rest of the map unit concept. The symbol $\frac{PR1}{5}$ tells the reader that the mapped area falls within the concept as defined and described for PR1 and the slope (5) is 5 to 15% (Table 298 provides a definition of the concept of PR1). The limits and systematic variations of the PR1 map units are defined in the Ecosite descriptions. Designing the legend so that there are a limited number of map unit concepts, effectively limits the number of individual decisions needed when extractive, interpretive maps are produced. Unlike the situation with open legends, where each map polygon must be considered individually, the closed legend allows interpretation of the map units in the legend only, followed by mechanical labeling of the appropriate map polygons.

With reference to the second guideline, because both soils and vegetation communities are distributed over the earth's surface in a continuum, the boundaries separating mapped individuals must be fixed by definition (Rowe 1961). It was apparent during the synthesis of soil and vegetation maps of Yoho National Park into a biophysical map that slight changes in mapping concepts would have resulted in coincident soil and vegetation boundaries being defined for many of the map polygons. Map unit boundaries for soils are normally placed where the rate of change in soil properites is the greatest. For example, a soil map unit boundary may be placed where a change in slope marks the transition between a uniform, till mantled valley wall and a level floodplain. According to Hills (1976), ecosystems are characterized by a central core or node with boundaries of convenience separating the nodes. By choosing to place a soils boundary at the till-floodplain boundary it often coincides with a change in vegetation (e.g. dry to moist vegetation) and thus conveniently defines a biophysical or ecological boundary. By appropriately defining the map boundaries it is possible to keep as co-varying most of the factors that would be identified in an open multifactor legend, thus reducing the number of combinations and permutations it is necessary to recognize. Valentine and Chang (1980) have shown that in soil maps with open legends, a few indentical combinations repeat very often, while many other combinations have only one representative map polygon. This suggests that these non-repeating combinations have only one differing factor and could be accommodated by a slight change in the concept or definition of an existing repeating group without any loss of understanding. An open legend allows a more complete cataloguing of information than a closed legend, but it is improbable that it allows the development of an ecological map unit concept, which the Canada Committee on Ecological (Biophysical) Land Classification has said is desirable (Jurdant et al. 1975, Rowe 1979).

By building the legend as outlined it is possible to develop a "named" holistic, repeating map unit concept; e.g. Panorama Ridge 1 (PR1). The detailed description of PR1, including photographs and diagrams, facilitates development of this conceptual "individual" so that whenever PR1 appears, so does a complete mental landscape image. If the map unit concepts have been so developed, a lay user, by identifying from the map the symbol for a familiar ecosystem, should be able to transfer to an unfamiliar area without necessarily appreciating fully the information associated with the map unit concept. Or, in more specific terms, at site A mapped as PR1 an existing trail has remained in good condition. Therefore at site B mapped as PR1 where no trail now exists, a trail could also be expected to be stable. No reference need be made to texture, lime or other specifics.

The third guideline is that the user of an ecological land classification map has the right to assume that the information presented is of uniform intensity and reliability throughout the area covered by the map. Since the location of map unit boundaries is established by definition, it may be, for example, that the make-up of map units in the Alpine areas is more complex than in the Montane areas, but once these concepts are defined, then they should be consistently recognized throughout the map sheet regardless

of ease of access. Adopting this principle has had a significant influence on mapping procedures. When the legend was being established, biophysical delineations were chosen to correlate as closely as possible with easily recognizable landscape features in order that reliable extrapolation of lines could be accomplished using aerial photographs. If after testing the map unit concept, it was impossible to consistently identify and delineate it, then the separation was not attempted because it would not be reliable. If a separation, which could not have been extrapolated using aerial photographs, had been deemed necessary to fulfill the purpose of the inventory, then it would have been necessary to field check all of the questionable separations to maintain uniform reliability throughout the mapped area.

Since the smallest area on a map into which the map symbol $\frac{PR1}{5}$ will fit is about 0.5 to 1 cm^2, this size has been chosen as the smallest area to be delineated. A 0.5 cm^2 area on the 1:50,000 map represents about 25-40 ha (50 to 100 acres), which provides a guideline to the smallest contrasting area (as stipulated by the legend) which it was possible to delineate.

In his statement on the philosophy of Ecological Land Classification in Canada, Rowe (1979) points out the need to differentiate between classification units and mapping units. The hierarchical units Ecoregion, Ecodistrict, Ecosection, and Ecosite are defined so that once members of the ecological population are subdivided they are not recombined at a lower hierarchical level. Attempts have been made to delineate polygons named in terms of a given hierarchical level and to subdivide those large polygons, naming the smaller units in terms of a lower category in the hierarchical taxonomy (Airphoto Analysis Associates 1975). This is the hierarchical or nested mapping method. When a closed legend is used, it becomes apparent that the nested mapping approach often segregates identical landscape delineated at a low categorical level within two larger, contrasting polygons, each being defined by different taxa at the next higher category. That is, while hierarchical organization of legends according to a taxonomic system is possible, it is not practical, at least in Banff-Jasper, to organize mapping in a hierarchical fashion.

The foregoing discussion of underlying principles provides the rationale used in making the choices amongst the various methodologies that have been recorded in the literature. They provide a sense of direction where a choice between alternatives is necessary.

MAPPING METHODOLOGY

B.D. Walker, I.G.W. Corns, W.S. Taylor and G.M. Coen

METHODOLOGY OF LEGEND DEVELOPMENT

No nationally acceptable taxonomic system for biophysical or ecological classification and mapping presently exists. There are, however, guidelines (Lacate 1969, Jurdant et al. 1975, Wiken 1980) useful in developing classification procedures. Therefore, the procedure used in Banff and Jasper has been to accept the landform and soil taxonomies as they exist, develop a vegetation "community type" taxonomy and combine these into a legend which defines the mapping units. There was no attempt to develop a taxonomy for ecological classification, instead leaving that activity to the Canada Committee on Ecological Land Classification. One of the problems that this created is that there was no existing taxonomy, with defined limits, with which to develop a tentative legend for mapping. Thus, mapping and mapping legends in the Banff-Jasper Ecological Land Classification have developed through a series of approximations.

Before beginning the routine mapping, a pilot project was undertaken which defined the four hierarchical levels of biophysical taxonomy. A tentative legend and guideline for its use were established and pretyping was undertaken for the areas to be mapped. Pretyped areas were then field checked and the mapping and legend refined in accordance with the findings of the field parties. Because of the lack of a well defined or established vegetation taxonomy, much of the emphasis for the first year or two was placed on the soil and landform criteria for defining mapping unit separations. In subsequent years, mapping units were defined more and more on the basis of vegetation types as they became more firmly established. There was often a soil change concomitant with a vegetation change, although not always of sufficient significance to establish a new Ecosection definition.

Field checking was done by a team consisting of one soil scientist and one vegetation scientist, both recording their observations at a mutually acceptable point on the landscape. The site specific information was recorded directly on computer forms or on standard forms which were easily transferred to computer entry format. This allowed mechanical manipulation and comparison of the 6000 to 7000 spot observations.

Corrections to the pretyping were noted and, during the following winter, adjustments were made to the lines on the aerial photographs

to finalize the map units. Each year the legend was readjusted to account for the changes in map unit concepts which developed over the summer season.

Mapping was done initially on 1:66,000 and 1:50,000 scale, black and white aerial photographs and later transferred to 1:50,000 base maps. Initial landscape stratification involved establishing Ecoregion, Ecoregion subunit, and genetic material unit boundaries within an area (Plates 82, 83). Superimposition of more detailed soil and vegetation information, organized at the Ecosite level in the Banff-Jasper Ecological Land Classification, produced the final mapping level with polygons named at the Ecosite level and modified by slope classes (Plate 84). In some cases, minor boundary adjustments of initial stratifications were necessary to accomplish the final step.

At the Ecosection and Ecosite levels, the mapping does not follow the nested mapping approach discussed previously. That is, the land is not stratified into polygons representing the Ecosection level (Plate 84). Further, the component parts (i.e. Ecosites) constituting an Ecosection do not necessarily exist contiguously on the landscape. For example, polygons mapped as PR1, PR2, PR3, PR4, and PR6 at the Ecosite level, frequently do not share boundaries to form a larger polygon called PR, representing the Ecosection level. Plate 84 illustrates this approach. Tracts mapped as PR2 and PR4 are generally isolated from each other and from PR1 and PR3. The PR6 Ecosite does not occur in Plate 84 and PR1 and PR3, in this instance, share a boundary. Nevertheless, Ecosystem entities (i.e. the aggregate that is PR) exist conceptually and the mapping legend is therefore hierarchical.

To complete the "biophysical" requirements of the inventory, wildlife observations were made by the Canadian Wildlife Service team during the following season to characterize the established map units. By characterizing "habitats" it was felt that predictive capability would be developed with relation to animals (or communities of animals) and Ecosite concepts. The iterative process of re-evaluation of Ecosite concepts, relative to the experience of the wildlife sector, allows for the identification of Ecosite concepts which would not have been justified or established on the basis of soils and vegetation parameters alone. The final ecological compilation presents Ecosite concepts which are defined not only in terms of their landform, soil, and vegetation components but which present concomitant wildlife parameters as well. The detailed methodology for wildlife inventory is presented in Volume III.

DESIGN OF THE MAPPING LEGEND

The current Ecological Land Classification guidelines (Wiken 1980) were taken as the starting point for developing the mapping legend used for the Banff-Jasper Ecological Land Classification. To develop the taxonomy, class limits should have been defined for each of the hierarchical levels and taxa within those levels. This would have resulted in a matrix of "pigeon holes" into which the ecological universe could be partitioned. Since only a portion of the ecological universe is present in Banff and Jasper it was impossible to develop credible taxon limits except for portions of the taxonomy. Thus, a mapping legend was developed with limits separating mapping concepts coincident to probable taxon limits wherever possible. The following discussion of Ecoregions, Ecosections, and Ecosites is in the context of how these taxonomic hierarchical levels influenced the mapping legend. Ecodistrict separations were not undertaken in the development of the legend.

ECOREGIONS

Three major Ecoregions (ecological zones) are represented in Banff and Jasper National Parks: Montane, Subalpine, and Alpine (Fig. 21). The Ecoregion is the broadest level of ecosystem classification used in this study and is based primarily upon differences in vegetation physiognomy and species composition which reflect differences in macroclimate. An Ecoregion, as used here, is conceptually similar to the zone of Daubenmire (1968) and La Roi (1975), the biogeoclimatic zone of Krajina (1965) and Kojima (1980), the biophysical region of Lacate (1969) and the Ecoregion of Wiken (1980) and Strong and Leggat (1981).

Montane Ecoregion

The Montane Ecoregion is the least extensive areally but is the most intensively used by man and of crucial importance to wildlife. In Banff, it extends from the Trans-Canada Highway east gate, upstream along the Bow valley to Johnston Creek. (Fig 21). A somewhat smaller area of Montane in Banff extends from the David Thompson Highway east gate up the North Saskatchewan and Howse rivers to Glacier Lake to the west, Arctomys Creek to the north, and to 5 km south of Saskatchewan Crossing. Modal elevations of the Montane Ecoregion in Banff range from about 1350 m, where the Bow River leaves Banff, to about 1500 m on north aspects and 1650 m on steep south exposures. These elevational ranges are similar for the Saskatchewan Crossing area with the lowest elevations being about 1400 m where the North Saskatchewan River leaves Banff.

The Montane Ecoregion in Jasper is more extensive than in Banff and is restricted to the Athabasca River valley and the lower parts of its tributaries (Fig. 21.) It extends from the Highway 16 east gate, upstream along the Athabasca River, including the lower reaches of the Fiddle, Rocky, Snake Indian, Snaring, Maligne, Astoria, and Whirlpool Rivers and Mosehorn Creek, to its southern extent near Sunwapta Falls. To the west, the Montane Ecoregion follows the Miette River valley to Jasper's West Gate. Modal elevations of the Montane in Jasper range from about 1000 m at the East Gate to about 1300 m on north aspects and 1400 m on steep south exposures (Fig. 22). An examination of Fig. 22 reveals that the Ecoregions of Banff are somewhat more compressed elevationally, than is the case in Jasper. Environmental factors, climatic or otherwise, that may account for this phenomenon are not apparent.

The vegetation of the Montane Ecoregion has developed in response to warm, dry air masses from central British Columbia moving eastward through the Vermilion, Kicking Horse, Howse and Yellowhead Passes into the Bow, North Saskatchewan and Athabasca valleys. Warm winter winds (chinooks) result in intermittent snow cover. Dry portions of the Montane on the valley bottoms and lower valley walls (e.g. AT3, HD4 and TA2 Ecosites) are characterized by the junegrass-pasture sage-wild flax (H6) v.t., while dry glacial and glaciofluvial slopes such as the Norquay Ecosection may have mature Douglas fir/hairy wild rye (C1) v.t. or where fire has been more frequent, lodgepole pine/juniper/bearberry (C3). More mesic situations on the valley walls and northerly aspects in the Montane are characterized by the white spruce-Douglas fir/feathermoss (C5) v.t. or the lodgepole pine/buffaloberry/showy aster (C6) v.t. and the lodgepole pine/buffaloberry/twinflower (C19) v.t.

Soils of mesic to subxeric, stable localities in the Montane Ecoregion are dominantly Eutric Brunisols, many exhibiting weak luvisolic tendencies. Genetically related Gray Luvisols are codominant on morainal landforms under similar moisture conditions. Regosolic soils are associated with active or recently active erosion and deposition. Various wet soils (Gleysolic and Organic soils) occur on wet terrain.

Subalpine Ecoregion

The Subalpine Ecoregion is cooler and moister than the Montane (Tables 2 and 3), occurs at elevations above the Montane Ecoregion and below the treeless Alpine and is characterized by continuous winter snow cover. The Subalpine Ecoregion is mainly forested, with Engelmann spruce and subalpine fir characteristic of mature forests. Lodgepole pine dominates successional forests but herb and shrub-dominated communities also occur, especially on wet terrain. The Subalpine Ecoregion is separated into Lower and Upper Subalpine portions on the basis of vegetation development and stand structure, reflecting differences in macroclimate.

The Lower Subalpine in Banff extends from approximately 1500 m to 1950 m on north aspects and from 1650 to 2050 m on steep south exposures. In Jasper elevations are 1300 to 1800 m on north aspects and 1400 to 1900 m on steep south exposures. The Lower Subalpine encompasses most of the closed forest (crowns separated by <2X crown width and >15-20% cover) of Banff and Jasper. In the Main Ranges, common lodgepole pine dominated v.t.s are lodgepole pine/buffaloberry/showy aster (C6), lodgepole pine/buffaloberry/twinflower (C19), lodgepole pine/buffaloberry/grouseberry (C18) and lodgepole pine/false azalea/grouseberry (C20). On sites with mature forest, common v.t.s are Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/false azalea (C14). In the Front Ranges, the moister v.t.s mentioned above, notably lodgepole pine/buffaloberry/grouseberry (C18), lodgepole pine/false azalea/grouseberry (C20), and Engelmann spruce-subalpine fir/false azalea (C14) are less prevalent. Several v.t.s, reflecting a drier climate found in the Front Ranges and occurring less frequently in the Main Ranges, are lodgepole pine/Labrador tea (C29), Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30), Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31), Engelmann spruce-subalpine fir/willow/hairy wild rye (O18) and willow/hairy wild rye (S12).

Soil variability is greater in the Lower Subalpine compared to the Montane. Mesic, stable localities on calcareous parent materials are dominated by Eutric Brunisols. Gray Luvisols are subdominant at lower elevations and on southerly aspects with pine forest. Dystric Brunisols have similar drainage regimes but occur on noncalcareous parent materials. Podzolic soils occur sporadically and are associated with Eolian material B veneers on cool, moist slopes with Engelmann spruce-subalpine fir vegetation. These are most abundant in western Banff and southwestern Jasper. Regosolic soils are associated with active or recently active erosion and deposition. Various wet soils, including Gleysolic, Organic, gleyed Brunisolic, and gleyed Podzolic soils, are associated with wet terrain. Lower Subalpine grassland soils (Regosols and Brunisols) in eastern Banff and Jasper often have thick (>10 cm) organo-mineral (Ah) horizons, but some of these may also be classified as Chernozemic soils (refer to Chapter II, Soils).

The Upper Subalpine portion of the Subalpine Ecoregion is characterized by open forests (crowns separated by 2-5X crown widths and <15-20% cover) and is transitional between the Lower Subalpine closed forests and the treeless Alpine. Upper Subalpine includes the krummholz ecotone which some authors (e.g. La Roi 1975) place in the Alpine. Compared with the Lower Subalpine, the Upper Subalpine climate is cooler and wetter with greater precipitation, later snow melt, and a shorter growing season. The Upper Subalpine in Banff extends from approximately 1950 to 2250 m on north aspects and from 2050 to 2350 m on steep south aspects. In Jasper, elevations are 1800 to 2150 m on north aspects and 1900 to 2250 m on south exposures. Vegetation is predominantly open forest dominated by Engelmann spruce and subalpine fir with representative v.t.s on cool, high elevation sites being Engelmann spruce-subalpine fir/heather (O10) and Engelmann spruce-subalpine fir/valerian-fleabane (O9). Closed forests such as Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21), Engelmann spruce-subalpine fir/grouseberry (C15) and, in southern Banff, subalpine larch-subalpine fir/grouseberry-everlasting (C23) occur at lower elevations within the Upper Subalpine, often on warmer south aspects, particularly in the Main Ranges and near the Continental Divide. In the Front Ranges of eastern Banff and Jasper, closed forest v.t.s such as Engelmann spruce-subalpine fir/rock willow/white mountain heather (C24), Engelmann spruce-subalpine fir/heather/feathermoss (C34), Engelmann spruce/hairy wild rye (C33) and hairy wild rye-junegrass-bearberry (H14) grasslands are more likely to occur, in response to a drier climate with less snowfall.

Soils of the Upper Subalpine are similar to those of the Lower Subalpine. Mesic, stable localities on calcareous parent materials are dominated by Eutric Brunisols. Dystric Brunisols have similar drainage regimes but occur on noncalcareous parent materials. Podzolic soils occur sporadically and are associated with altered, medium textured Eolian material B veneers. These are most abundant in western Banff and southwestern Jasper. Regosolic soils are associated with active or recently active erosion and deposition. Soils of the Upper Subalpine-Alpine ecotone, dry shrubland, and grassland areas usually have organo-mineral (Ah) horizons, in many cases exceeding 10 cm in thickness (Melanic Brunisols, Sombric Brunisols, and Humic Regosols). Some of these soils on steeply sloping grasslands may also be classed as Chernozemic soils (refer to Chapter II, Soils). Cryosolic soils are common on steep, forested (spruce-fir), northerly aspects in the Front Ranges subprovince on genetic material derived from Mesozoic strata. Various wet soils, including Gleysolic, Organic, gleyed Brunisolic, and gleyed Podzolic soils, are associated with wet terrain.

Alpine Ecoregion

The treeless Alpine Ecoregion occurs above the Upper Subalpine and reflects a cold, harsh climate (ET - Koeppen system; Trewartha 1957). Alpine vegetation typically forms a complex, fine-scale mosaic in which microclimate variations are reflected by marked changes in dominant species and v.t.s. Important microclimatic factors include aspect, wind exposure, time of snowmelt, snow depth, soil moisture and soil physical - chemical characteristics. The most common v.t.s in the Main Ranges and near the Continental Divide are heather-everlasting (L5) in high snowfall areas, mountain avens-snow willow-moss campion (H1) on wind exposed sites and white mountain heather-mountain avens-snow willow (L4) on moderately deep snowbed sites. In the Front Ranges in eastern Banff and Jasper, the heath-dominated v.t.s are less prominent with the H1 v.t. assuming greater importance. In addition, a characteristic Front Range v.t. mountain avens-kobresia-bearberry (H4) occurs. The highest elevation communities are usually saxicolous lichen (H12) tundra on rock and shallow soils. The H12 v.t. is best developed on acidic rocks especially quartzites in the Main Ranges.

Alpine soils, like vegetation, form a complex, fine-scale mosaic. Their distribution is governed by depth, distribution, kind and stability of parent materials, exposure, and depth of organo-mineral (Ah) horizon accumulation across the landscape. Brunisolic soils are abundant. Eutric (<10 cm of Ah) and Melanic (>10 cm of Ah) Brunisols are associated with stable, calcareous, parent materials under mesic moisture conditions. Dystric (<10 cm Ah) and Sombric (>10 cm of Ah) Brunisols are associated with stable, noncalcareous, parent materials under similar moisture conditions. Podzolic soils occur sporadically and are associated with Eolian material B veneers. These are most abundant in western Banff and southwestern Jasper. Active and recently active geomorphic processes (both erosional and depositional) are important in the Alpine Ecoregion, hence Regosolic soils, with varying thicknesses of Ah horizon, are abundant. These processes include wind erosion and deposition, colluviation, fluvial activity, solifluction, and cryoturbation. Shallow soils are often Regosolic and grade to nonsoil on high elevation, feral Alpine slopes. Wet soils are important locally.

Alpine subunits cannot be delineated even at a 1:50,000 scale, so the Alpine Ecoregion of this report includes the lower, middle and part of the upper subzones of La Roi (1975).

Much of the upper subzone is frequently mapped as Rockland (R) or Colluvial Rubble (CR).

ECOSECTIONS

Ecoregions are divided into 55 Ecosections. The Ecosections are named after geographic features, and assigned a two letter, connotative symbol. The limits of the classes of Ecosections are based on broad differences in genetic materials and drainage classes as reflected by landform features. Variations in genetic materials that result in the establishment of Ecosections are glacial (including morainal and ice contact stratified), glaciolacustrine, glaciofluvial, fluvial (including fluviolacustrine), colluvial, landslide, eolian, and residual (Table 95). These eight classes are subdivided into two groups based on moisture regime. Wet terrain includes land areas dominated by soils classed as poorly drained and very poorly drained (C.S.S.C. 1978a), i.e. hygric to hydric site moisture regimes. Non-wet terrain includes land areas dominated by soils classed as moderately well drained and drier, i.e. mesic to xeric moisture regimes. Land areas dominated by imperfectly drained soils are placed in either the wet or non-wet group, depending upon the moisture regime of the predominant vegetation and associated soils and vegetation.

For pragmatic reasons, further subdivision of wet terrain is inappropriate. Where necessary land areas dominated by non-wet terrain are further subdivided according to one or more of the following criteria:

1. Calcareous versus noncalcareous genetic materials;
2. Three genetic material textural groups, two of which are used for Ecosection separations within certain genetic material classes;
3. Five soil-vegetation classes reflecting geomorphic activity and/or mesoclimatic differences;
4. Landform surface expression.

The first two criteria are also used in making genetic material unit separations described in the Geomorphology section (Chapter I) and summarized in Table 6. Table 96 shows, as an example, the organization of Lower Subalpine Ecosections associated with glacial genetic materials.

Calcareous Versus Noncalcareous Genetic Materials.

Reaction and calcareousness of soils were described using 6 classes (C.S.S.C. 1978a) or combinations thereof. In the Banff-Jasper Ecological Land Classification legend two groups, noncalcareous and calcareous, are used for Ecosection separations. Borderline situations, such as weakly calcareous materials or materials with lime at considerable depth from the soil surface, are placed in either class, the decision being influenced by factors such as extent, pH of solum, texture, major lithological source and vegetation. Some genetic materials of limited extent or heterogeneous chemical characteristics are not further subdivided at the Ecosection level.

Table 95 Organization of Ecosections by Ecoregion and genetic material classes.

Genetic Material	Ecoregions and Subdivisions			
	Montane	Subalpine		Alpine
		Lower	Upper	
Residual	-	BZ	CP	HE
Landslide	GA	IB	BP	-
Colluvial	-	FV, SB	EN, WH, WF	BS, RD, TK
Glacial (morainal plus ice contact stratified)	PT, NY	BK, BY, CA, CV*, GT, ML, PR, (TZ)‡, WW †	AZ, EG, LV, PL, SF, SX*, TR	EF, JN, MP
Glaciofluvial	AT	BV, (TZ)	NG	-
Fluvial (including fluviolacustrine)	FR, HD, VL*	AL, HC*, PP, VD	CN, MQ, NT*	KA
Glaciolacustrine	NH*, RK	MC*, SP	-	-
Eolian	DV, TA	-	-	-

* Dominantly wet terrain

† Refer to Table 96

‡ The TZ Ecosection is defined as being associated with two genetic material classes

Table 96 Example of Ecosection separations with glacial genetic materials (refer to Table 95) in the Lower Subalpine Ecoregion.

Glacial Genetic Materials of the Lower Subalpine								
Dominantly Wet Terrain	Dominantly Non-wet Terrain							
	Noncalcareous			Calcareous				
	Medium Texture	Coarse Texture		Dominantly Medium Texture				
		Morainal	Ice contact stratified	Regosolic herb	Brunisolic-Regosolic pine or grassland-pine	Brunisolic-Luvisolic pine	Brunisolic-Podzolic spruce-fir	Dry>wet pattern
CV	CA	ML	(TZ)*	WW	GT	PR†	BY	BK

* Subdominant genetic material is noncalcareous, coarse textured glaciofluvial

† Refer to Table 97

Genetic Material Textural Classes

Textural classes (C.S.S.C. 1978a) can be combined in a variety of ways for various purposes. In the Banff-Jasper survey, three broad textural groups were recognized:

a. Coarse textured genetic materials, derived mainly from medium and coarse grained clastic bedrock, usually have more than 60% sand and include the sand, loamy sand, and part of the sandy loam textural classes;

b. Medium textured materials, derived mainly from medium to fine grained carbonate and clastic bedrock, most commonly including the loam, silt loam, and part of the sandy loam textural classes;

c. Fine textured materials, deposited primarily by still water sedimentation, including clay loam, silty clay loam, and silty clay textural classes.

Only the coarse and medium textured groups are used for making separations at the Ecosection level and then, only for genetic materials which have textural characteristics related to the lithological sources (e.g. morainal material, Table 96), provided that each group is of sufficient areal extent and homogeneity to be separated. Textural characteristics of glaciofluvial, fluvial, glaciolacustrine, and eolian genetic materials are a function of the depositional agents. Therefore, further separation is unnecessary at the Ecosection level. The fine textured group applies to glaciolacustrine sediment and to fluviolacustrine sediment generally contained within fluvial landforms. Hence, it is more useful for making separations at the Ecosite level rather than the Ecosection level. Fine textured genetic materials derived from fine grained, calcareous, clastic bedrock do occur (e.g. fine textured morainal material) but are of limited areal extent and are not separated. Stratified materials such as fluvial (including fluviolacustrine) deposits were not subdivided into Ecosections according to the above textural criteria because of the wide textural variation within small delineations.

Soil-Vegetation Classes Reflecting Geomorphic Activity and/or Mesoclimate

Certain differences in soil and vegetation development are thought to reflect mesoclimatic differences or recent geomorphic activity and thus are used to make Ecosection separations. The five classes are defined as follows:

a. Land areas dominated by Regosolic soils and other soils with weak profile development (e.g. WW Ecosection, Table 96). These areas are influenced by recent soil erosion or deposition. A wide variety of vegetation types are associated with Regosolic soils;

b. Land areas dominated by Brunisolic soils with thin sola and associated Regosolic soils (e.g. GT Ecosection, Table 96). Both recent soil disturbances (erosion or deposition) and mesoclimatic factors (mainly aspect) influence soil and

vegetation development. Associated vegetation types are predominantly mesic to subxeric lodgepole pine forest, Douglas fir forest, grassland, and dry to moist shrubby vegetation;

c. Land areas dominated by Brunisolic soils with associated Luvisolic or luvisolic-like soils (e.g. PR Ecosection, Table 96). Associated vegetation types are mostly mesic lodgepole pine forests;

d. Land areas dominated by Brunisolic and Podzolic soils, generally found above 1500 m and in moister areas (e.g. BY Ecosection, Table 96). Associated vegetation types are predominantly mesic to subhygric Engelmann spruce-subalpine fir forests;

e. Land areas dominated by Cryosolic soils with associated Engelmann spruce-subalpine fir forest (i.e. SF Ecosection, Table 95).

The first two classes are related to current or recent geomorphic activity, in particular fluvial and colluvial materials. Class "a" does not strongly reflect mesoclimatic influences. In both cases, vegetation types are more likely to reflect mesoclimatic differences than are the soils. On steep colluvial slopes, in order to emphasize the instability of materials, Ecosection distinctions were not made among classes "a" through "e" above.

Classes "b" to "e" represent a subdivision of the mesoclimatic continuum from warm and dry to cool and moist into three groups. The continuum results from orographic change (east to west), aspect differences (southerly versus northerly exposures), and/or altitudinal change (lower to higher). Some of the separations into the five classes may not clearly reflect mesoclimatic differences. Parent material characteristics are particularly important in some cases. Examples are the presence of Eolian material B related to the occurrence of Podzolic soils and the influence of Mesozoic strata on the development of Cryosolic soils.

Landform Surface Expression Producing a Dry >Wet Landscape

Most parent material changes are accompanied by landform surface expression changes and thus, few Ecosection separations are based on landform surface expression alone. Hummocky glacial landforms producing a dry > wet landscape pattern are a major exception. The distinct repeating dry and wet pattern resulting in complex soil-vegetation relationships (as in the BK Ecosection, Table 96) is sufficiently different from the uniformly sloping dry pattern of inclined glacial landforms (as in the PR Ecosection) to warrant separation at the Ecosection level. The dry and wet components are distinct but cartographically inseparable. This criterion applies, at the Ecosection level, only to glacial landforms of the Lower Subalpine where this complex landscape is most extensive.

As with any criteria defining cartographic concepts, individuals falling close to class boundaries may be more like each other than like the different central concepts to which they belong. Thus, cartographic separations involving a continuum always necessitate some arbitrary decisions as to which class a given individual may belong. The guidelines above are considered reasonably precise with regard to the central concepts of the classes and have resulted in decisions which produce a useful organization of the natural phenomena being mapped.

ECOSITES

The 55 Ecosections have been further separated into 124 Ecosites and named as numerical subdivisions of the Ecosection name, e.g. the Ecosection name PR is subdivided by numerals to give PR1, PR2, PR3, etc. The subdivisions are made on the basis of physiognomic and, to some extent, floristic differences in vegetation as well as differences in soil parameters. Factors limiting the implementation of these criteria or the degree to which they are used include scale of mapping, ease of photographic interpretation, and areal extent of the proposed Ecosite definition.

Generally, subdivision of Ecosections into Ecosites is based on the following criteria.

Physiognomic Groupings

Land areas with differing physiognomic groupings of vegetation that were not previously separated at higher levels in the mapping hierarchy are separated when they differ with respect to the following:

a. Land areas having closed forests (see definition in vegetation section, Chapter III) as the predominant vegetation physiognomy;

b. Land areas having open forests (see definition in vegetation section, Chapter III) as the predominant vegetation physiognomy;

c. Land areas having shrubs as the predominant vegetation physiognomy;

d. Land areas having low shrubs and herbs as the predominant vegetation physiognomy;

e. Land areas having herbs as the predominant vegetation physiognomy.

Habitat Grouping

Land areas, not previously separated at the Ecosection level, with selected vegetation type groupings useful in the identification of wildlife habitat (D. Karasiuk, G. Holroyd, CWS, Edmonton, personal communications) are separated as follows:

a. Land areas having poplar forest as the predominant vegetation;
b. Land areas having lodgepole pine forest as the predominant vegetation;
c. Land areas having lodgepole pine/buffaloberry forest as the predominant vegetation;
d. Land areas having Engelmann spruce-subalpine fir forest as the predominant vegetation;
e. Land areas near timberline having a mosaic of heath tundra plus scattered Engelmann spruce-subalpine fir trees, tree islands, or krummholz as the predominant vegetation;
f. Land areas having subalpine larch forests as the predominant vegetation;
g. Land areas having avalanche complex (shrubs and herbs) as the predominant vegetation.

Genetically Similar Soil or Landform Parameters.

Soil parameters not previously used to make separations at the Ecosection level and not necessarily identified with covarying vegetation type or physiognomy differences result in the following separations:

a. Land areas dominated by imperfectly drained soils (Gleyed subgroups) are separated from land areas having dominantly moderately well drained and drier soils;
b. Land areas dominated by Brunisolic soils are separated from land areas having dominantly Brunisolic-Regosolic soils or Brunisolic-Podzolic soils. Such separations are not appropriate at the Ecosection level because the land areas involved are of limited areal extent and because pedogenic differences are minor;
c. Land areas dominated by ice contact stratified drift are separated from land areas dominated by morainal deposits.

Complex Map Units

Land areas comprised of two distinct but cartographically inseparable soil-vegetation components, not previously used to make separations at the Ecosection level, are separated as follows:

a. Land areas comprised of distinct northerly and southerly aspects, as reflected by major differences in soil and vegetation are separated from land areas comprised mainly of either end member;
b. Land areas comprised of a distinct wet and dry pattern of soils and vegetation are separated from land areas comprised mainly of either end member;
c. Land areas having vegetation type distributions controlled by shallow parent materials, involving lithic and non-lithic or non-soil and lithic soil patterns, are separated from land areas with deeper soils and a comparatively uniform vegetation type cover.

Table 97 gives an example of the subdivision of an Ecosection into its component Ecosites. Soil and vegetation differences used to define Ecosites are considered insufficient in magnitude or kind to warrant separations at the Ecosection level. An attempt was made to define repeating natural Ecosite concepts so that differences among central concepts are of equal magnitude. Having established this statement as a model, it is very difficult to evaluate whether the diverse differentiating criteria, in aggregate, give the desired results.

Table 97 Example of Ecosite separations within an Ecosection.

Ecosite	Landform*	Soils	Vegetation†
PR1	Till C blankets overlying inclined bedrock	Eutric Brunisols > Gray Luvisols	lodgepole pine/false azalea, lodgepole pine/feathermoss, lodgepole pine/Labrador tea
PR2	Till C blankets overlying inclined bedrock	Eutric Brunisols > Gray Luvisols	logepole pine/buffaloberry
PR3	Till C blankets overlying inclined or hummocky bedrock, hummocky Till C	gleyed Eutric Brunisols > gleyed Gray Luvisols	lodgepole pine forest
PR4	inclined Till C and Ice Contact Stratified Drift B	Northerly aspects: Eutric Brunisols Southerly aspects: Eutric Brunisols > Gray Luvisols, Regosols	Northerly aspects: Engelmann spruce - subalpine fir forest Southerly aspects: logepole pine forest
PR6	Ice Contact Stratified Drift B blankets overlying inclined or hummocky bedrock, hummocky Ice Contact Stratified Drift B	Eutric Brunisols > Gray Luvisols	lodgepole pine forest

* **Landform** —Specific genetic material units are presented; refer to Geomorphology section, and Table 6.

† **Vegetation** —In order to differentiate PR1 from PR2, vegetation is presented at a more detailed level of description than for the other PR Ecosites.

ECOSECTION/ECOSITE DESCRIPTIONS

B. D. Walker, W. S. Taylor, D. T. Allan, and R. E. Wells

INTRODUCTION

A comprehensive discussion of each ecological mapping concept used in the Banff-Jasper Ecological Inventory is provided in this section. The Ecosection descriptions are arranged in alphabetical order for ease of referencing. Tables, figures and plates are provided to illustrate the Ecosite concepts. Fig. 29 provides a legend identifying the components of the schematic cross section diagrams.

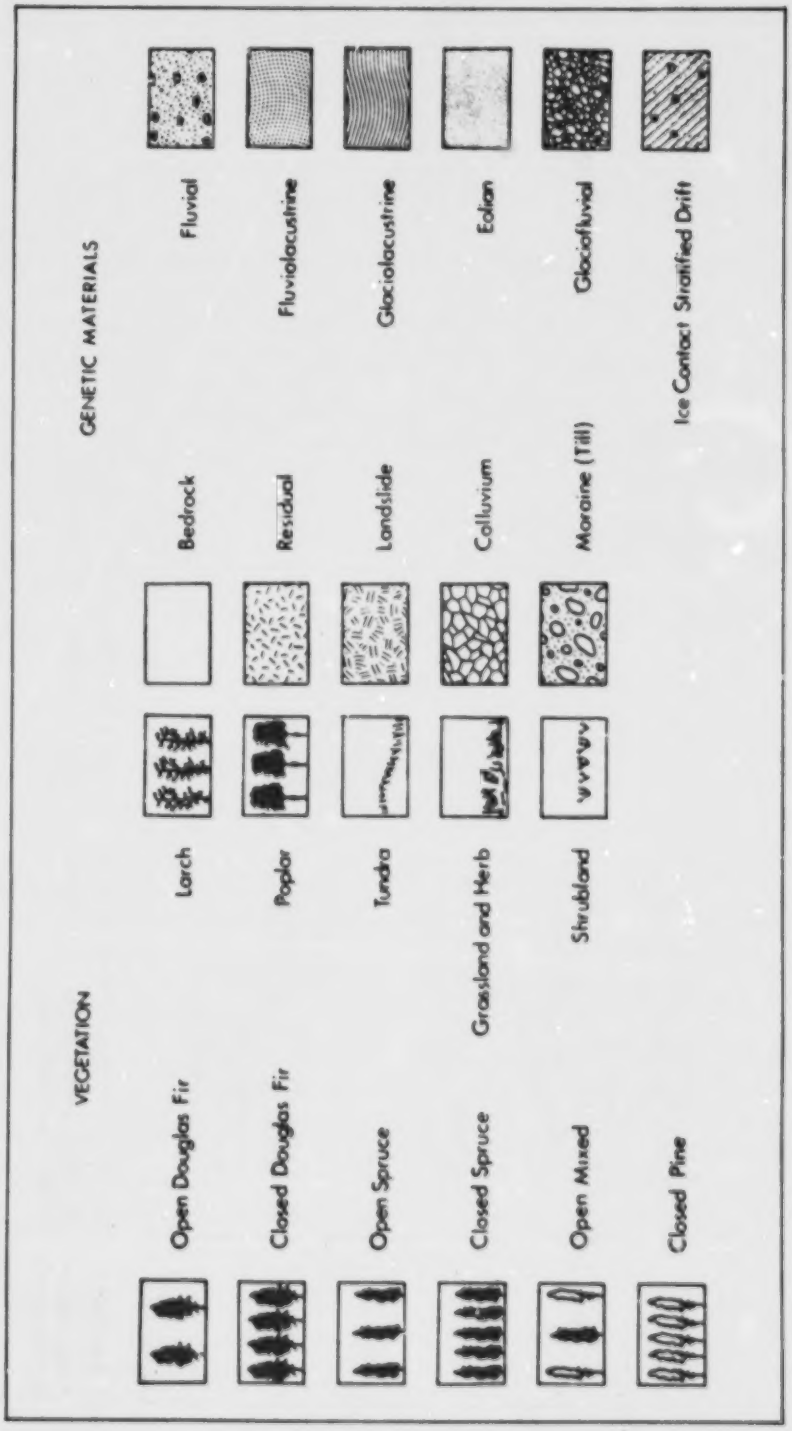


Figure 29 Legend identifying components of the schematic cross section diagrams illustrating the Ecosite descriptions.

AL - ALTRUDE ECOSECTION

The Altrude Ecosection encompasses relatively stable fluvial landforms comprised of calcareous, coarse, stratified fluvial material (Fluvial material B) within the Lower Subalpine portion of the Subalpine Ecoregion. Brunisolic soils associated with lodgepole pine and Engelmann spuce-subalpine fir forests dominate this Ecosection. The AL Ecosection occupies lower slopes and valley floors of main and tributary valleys in both parks.

Two Ecosites are differentiated (Table 98) within the Altrude Ecosection based on vegetational differences.

Table 98 General features of the Altrude (AL) Ecosites.

Ecosite	Landform	Soils	Vegetation
AL1	Fluvial material B; fan, apron	Eutric Brunisol	lodgepole pine forest
AL2	Fluvial material B; fan, apron	Eutric Brunisol	Engelmann spruce-subalpine fir forest

AL1 - ALTRUDE 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, AL1, occurs on relatively stable fluvial fans and aprons consisting of calcareous, coarse, stratified fluvial material (Fluvial material B) and is dominated by well drained Orthic and Eluviated Eutric Brunisols and the lodgepole pine/buffaloberry/twinflower (C19) v.t.

Geomorphology

The AL1 Ecosite occurs on relatively stable fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). Land mapped as AL1 commonly has linear slopes between 2% and 45%. Surficial veneers of altered, medium textured eolian material (Eolian material B) thinly mantle those AL1 tracts with the oldest surfaces especially in western Banff and southwestern Jasper. Irregular surfaces produced by channeling (Eroded modifier, C.S.S.C. 1978b) are a common feature of the AL1 Ecosite. Other fluvial landforms occasionally found in AL1 tracts include veneers, blankets and level plains. Veneers and blankets of Fluvial material B usually overlie morainal landforms or, occasionally, colluvial aprons and fans, glaciofluvial fans and terraces or glaciolacustrine blankets.

Soils

The AL1 Ecosite is characterized by well drained Orthic and Eluviated Eutric Brunisols. The degree of development of these soils reflects geomorphic stability. Narrow strips dominated by Orthic and Cumulic Regosols occur along present and recently abandoned stream channels. These soils reflect a more active environment and may be subject to erosion or flooding during spring run-off and periods of high precipitation. Eutric Brunisols with Btj horizons, Brunisolic Gray Luvisols and Orthic Gray Luvisols were found on a few tracts of AL1 but Luvisolics occur very rarely. The following pedon description (Table 99) illustrates an Orthic Eutric Brunisol of the AL1 Ecosite.

Table 99 Pedon (Alberta 1974 No. 105) description of an Orthic Eutric Brunisol of the AL1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: AL1.

LOCATION: MILITARY GRID REF. 11 UNS 6550 8820; NTS MAP AREA 82N 8E.

CLIMATE: 1495 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS MODERATE RELEVANCE TO THE SOIL SITE.

SOIL SITE: PARENT MATERIAL 1: SANDY, MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), FLUVIAL; LANDFORM CLASSIFICATION: FLUVIAL, FAN; SLOPE: 1.5% SIMPLE SLOPE OF CLASS 2 (0.5-2%), FACING SOUTHWEST, SITE AT MIDDLE POSITION, LEVEL MICROTOPOGRAPHY.; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS; NONSTONY; NONROCKY.

SPECIAL NOTES: SSH=DA4079*RLU=15*PCF=1GR+CB(2)2GR+CB(3)6GR+CB(4-5)*AE NOT SAMPLED*APN=783-78

LF: 4 TO 0 CM, RANGE 3 TO 5 CM; HORIZON MOIST; CRUSHED MOIST 10YR 2/1; MATERIAL COMPOSITION SLIGHT AND MODERATE DECOMPOSITION; ABUNDANT, FINE AND MEDIUM ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 1 CM, RANGE 0 TO 1 CM; HORIZON DRY; CRUSHED DRY 10YR 7/2; SANDY LOAM; WEAK, FINE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE, ABUNDANT, FINE AND MEDIUM ROOTS; BROKEN, ABRUPT HORIZON BOUNDARY.

BM: 1 TO 18 CM, RANGE 15 TO 20 CM; HORIZON DRY; CRUSHED DRY 7.5YR 5.5/6; LOAM; MODERATE, FINE, PLATY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

BMK: 18 TO 46 CM, RANGE 20 TO 40 CM; HORIZON DRY; CRUSHED DRY 5YR 5/8; VERY GRAVELLY COARSE SANDY LOAM; SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE AND MEDIUM ROOTS; MODERATELY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK: 46 TO 67 CM; HORIZON DRY; CRUSHED DRY 10YR 6/3; VERY GRAVELLY LOAMY SAND; SINGLE GRAIN STRUCTURE; LOOSE, LOOSE CONSISTENCE; STRONGLY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.3	49.20		61.3		20.8	5.1	0.1	3.6
AE									
BM	5.6	0.90		9.4		4.1	1.0	0.1	0.3
BMK	7.1	0.10	9.6	5.7		10.2	2.2	-.1	0.1
CK	7.0		16.5	2.7		9.1	1.2	-.1	0.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	0.1		0.1	
BMK	0.1		-.1	
CK				

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIZE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE														
BM					5	7	8	12	13	45		48	7	1
BMK					18	18	16	11	6	69		19	12	3
CK					7	28	30	12	4	81		13	6	3

Vegetation

The AL1 Ecosite is dominated by the mesic lodgepole pine/buffaloberry/twinflower (C19) v.t. Lodgepole pine/buffaloberry/showy aster (C6) and lodgepole pine/buffaloberry/grouseberry (C18) are accessory v.t.s. Inclusion of v.t.s lodgepole pine/feathermoss (C11), lodgepole pine/false azalea/grouseberry (C20) and lodgepole pine/Labrador tea (C29) also occur on AL1. These v.t.s commonly have spruce in the understory. V.t. lodgepole pine/dwarf bilberry (C9) is found on AL1 in southern Banff. Minor amounts of spruce dominated v.t.s may also occur in small patches, especially associated with Regosolic soils. Table 100 and Plate 85 represent the C19 v.t. commonly found on AL1 Ecosites. This vegetation plot was described on a fluvial fan approximately three km east of the soil pedon site.

Table 100 Stand (AW5009) illustrating the lodgepole pine / buffaloberry / twinflower (C19) v.t. of the AL1 Ecosite.

TREE LAYER	
Picea glauca	05
Pinus contorta	35
Populus tremuloides	03
SHRUB LAYER	
Juniperus communis	.5
Lonicera involucrata	.5
Rosa acicularis	02
Salix glauca	01
Shepherdia canadensis	04
HERB-DWARF SHRUB LAYER	
Achillea millefolium	.5
Arctostaphylos uva-ursi	01
Arnica cordifolia	01
Calypso bulbosa	.5
Carex concinna	.5
Cornus canadensis	03
Elymus innovatus	04
Epilobium angustifolium	.5
Fragaria virginiana	02
Galium boreale	.5
Linnaea borealis	03
Pyrola asarifolia	01
Pyrola secunda	.5
Senecio indecorus	.5
Ranunculus spp.	.5
Vaccinium caespitosum	01
Vaccinium vitis-idaea	06
BRYOID LAYER	
Peltigera aphthosa	01
Pleurozium schreberi	60

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The AL1 Ecosite most closely resembles the Pipestone 1 (PP1), Verdant 2 (VD2), and Fireside 1 (FR1) Ecosites in terms of landform and vegetation. The PP1 Ecosite is dominated by Orthic and Cumulic Regosols that reflect a more active geomorphic environment. The VD2 Ecosite occurs on fluvial landforms consisting of noncalcareous, coarse, stratified fluvial material (Fluvial material A) and is dominated by acidic soils, and FR1 is separated because it occurs in the Montane Ecoregion.

Mapped tracts designated as AL1A have 20 to 50% of their area modified by snow avalanching.

AL2 - ALTRUDE 2 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, AL2, occurs on fluvial fans and aprons consisting of calcareous, coarse, stratified fluvial material (Fluvial material B). The AL2 Ecosite is dominated by well to moderately well drained Orthic and Eluviated Eutric Brunisols associated with Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t.s.

Geomorphology

The AL2 Ecosite occurs on fluvial fans and aprons consisting of calcareous, coarse, stratified fluvial material (Fluvial material B). Land mapped as AL2 commonly has linear slopes between 2% and 45%. Surficial veneers of altered, medium textured eolian material (Eolian material B) thinly mantle those AL2 tracts with the oldest surfaces, especially in western Banff and southwestern Jasper. Irregular landform surfaces produced by channeling is a common feature. Other fluvial landforms occasionally found in AL2 tracts include veneers, blankets and level plains. Veneers and blankets of Fluvial material B usually overlie morainal landforms or, occasionally, colluvial aprons and fans, glaciofluvial fans and terraces, or glaciolacustrine blankets.

Soils

The AL2 Ecosite is dominated by well to moderately well drained Orthic and Eluviated Eutric Brunisols. The degree of development of these soils reflects geomorphic stability. Narrow strips dominated by Orthic and Cumulic Regosols occur along present and recently abandoned stream channels. These soils reflect a more active environment and may be subject to erosion and flooding during spring run-off and periods of high precipitation. Eutric Brunisols with Btj horizons and Brunisolic Gray Luvisols were found on a few AL2 polygons but Luvisolics occur very rarely. A pedon illustrating Orthic Eutric Brunisols of the AL2 Ecosite is described in Table 101 and shown in Color Plate 1.

Table 101 Pedon (Alberta 1978 No. 216) description of an Orthic Eutric Brunisol of the AL2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: AL2.

LOCATION: MILITARY GRID REF. 11 UNG 9890 8640; NTS MAP AREA 820 SE.

CLIMATE: 1640 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 8 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPH=JC8681=VTH=C13=.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, SANDY, EXTREMELY CALCAREOUS (>40% CACO3), FLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: FLUVIAL, FAN; SLOPE: 10% SLOPE OF CLASS 3 (10-15%), FACING NORTHWEST, SITE AT MIDDLE POSITION, MODERATELY MOUNDED MICROTOPOGRAPHY,800 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; [illegible]EDINGLY STONY.

SPECIAL NOTES: SBN=GC8036=ARH=010-180=PCP=2BR,2CB(3)36R,3CB(4)48R,3CB(5)48R,3CB(6)=

LF: 10 TO 0 CM, RANGE 5 TO 10 CM; MATRIX MOIST 10YR 3/2, MATRIX MOIST 10YR 3/4; PLENTIFUL, MICRO AND FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 1 CM, RANGE 0 TO 3 CM; MATRIX MOIST 10YR 5/2; VERY FINE SANDY LOAM; WEAK, MEDIUM, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; FEW, VERY FINE PORES; GRAVELLY AND COBBLY COARSE FRAGMENTS; BROKEN, CLEAR HORIZON BOUNDARY.

BM1: 1 TO 15 CM, RANGE 6 TO 15 CM; MATRIX MOIST 10YR 5/6, MATRIX MOIST 10YR 4/4; SILT LOAM; VERY WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; MANY, VERY FINE PORES; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

BM2: 15 TO 22 CM, RANGE 6 TO 10 CM; MATRIX MOIST 10YR 5/3; SILT LOAM; VERY WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; COMMON, VERY FINE PORES; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

CK1: 22 TO 57 CM, RANGE 30 TO 40 CM; MATRIX MOIST 10YR 4/2; GRAVELLY SANDY LOAM; SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

CK2: 57 TO 80 CM; MATRIX MOIST 10YR 5/2; GRAVELLY LOAMY SAND; SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.2	45.30							
AE									
BM1	5.4	4.80		35.2		10.8	1.5	0.1	0.2
BM2	6.7	3.00		24.6		10.1	2.4	0.1	0.2
CK1	7.2		57.5						
CK2	7.5		57.7						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM1	0.1		0.2	
BM2	-.1		-.1	
CK1				
CK2				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 78-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE														
BM1					2	8	4	6	10	27		47	6	
BM2					4	5	8	7	10	33		52	15	
CK1					15	17	13	11	6	62		38	3	
CK2	99	66	38	28	22	22	17	13	5	79		20	1	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE													
BM1		35.7	14.8										
BM2													
CK1		10.8	3.8										
CK2		7.6	1.8									11	01

Vegetaton

The AL2 Ecosite is dominated by mesic Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t.s. The C13 v.t. occurs more often than C31 on AL2. However, many AL2 tracts located in eastern portions of both parks are dominated by C31. Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) occurs as an accessory on some AL2 tracts located in the Front Ranges subprovince. Small amounts of lodgepole pine/feathermoss (C11), Engelmann spruce-subalpine fir/false azalea (C14), white spruce/buffaloberry/fern moss (C26) and Engelmann spruce/horsetail/feathermoss (C32) v.t.s may also be found on some AL2 tracts but occur rarely. Table 102 and Plate 86 illustrate the Engelmann spruce-subalpine fir/feathermoss (C13) v.t. commonly found on AL2.

Table 102 Stand (JC8081) illustrating the Engelmann spruce-subalpine fir / feathermoss (C13) v.t. of the AL2 Ecosite.

TREE LAYER	
Picea engelmannii	50
Pinus contorta	.5
TALL SHRUB LAYER	
Abies lasiocarpa	.5
Picea engelmannii	.5
SHRUB LAYER	
Abies lasiocarpa	.5
Picea engelmannii	.5
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	.5
Arnica cordifolia	.5
Cornus canadensis	01
Elymus innovatus	.5
Ledum groenlandicum	.5
Linnaea borealis	.5
Picea engelmannii	.5
Pyrola secunda	.5
Rosa acicularis	.5
Vaccinium scoparium	.5
BRYOID LAYER	
Cladonia cornuta	.5
Cladonia fimbriata	.5
Cladonia gracilis	01
Dicranum fuscescens	.5
Hylocomium splendens	70
Lophozia spp.	.5
Peltigera aphthosa	04
Pleurozium schreberi	20
Pohlia nutans	.5
Polytrichum juniperinum	.5
Ptilium crista-castrensis	05
Ptilidium ciliare	.5
Stereocaulon tomentosum	.5
EPIPHYTES	
Bryoria glabra	.5
Letharia vulpina	.5
Parmelia sulcata	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

This vegetaton plot represents vegetaton at the pedon sample site described above in Table 101.

Discussion

The Altrude 2 Ecosite most closely resembles the Pipestone 3 (PP3) and Verdant 1 (VD1) Ecosites in terms of landform and vegetation. The PP3 Ecosite differs because it is dominated by Orthic and Cumulic Regosols that reflect a more active geomorphic environment. The VD1 Ecosite is different because it occurs on fluvial landforms comprised of noncalcareous, coarse, stratified fluvial material (Fluvial material A) and is dominated by acidic soils.

Mapped tracts designated as AL2A have 20% to 50% of their area modified by snow avalanching.

AT - ATHABASCA ECOSECTION

The Athabasca Ecosection occurs on calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) in the Montane Ecoregion. Eutric Brunisols are the dominant soils, with the vegetation being lodgepole pine forest, or a pattern of this forest and dry grassland.

The AT Ecosection is found frequently and with greatest extent on broad valley floors and lower benchland throughout the Montane in Banff and Jasper. Extensive examples are mapped along the floor of the Athabasca River valley from the Snaring to the Sunwapta Rivers.

Two Ecosites (AT1, AT3) are defined mainly by differences in vegetation. Table 103 outlines general features of the AT Ecosites.

Representations of AT1 on the landscape are presented in Figs. 47 and 50. The AT3 Ecosite occupies similar landscape positions.

Landform genesis of the AT Ecosection can be compared to the presently actively aggrading glaciofluvial landform of the Pipestone 4 (PP4) Ecosite.

Table 103 General features of the Athabasca (AT) Ecosite.

Ecosite	Landform	Soils	Vegetation
AT1	Glaciofluvial material B; terrace	Eutric Brunisol	lodgepole pine forest
AT3	Glaciofluvial material B; terrace	Eutric Brunisol	dry grassland > lodgepole pine forest

AT1 - ATHABASCA1 ECOSITE

Ecosite Concept

The AT1 Ecosite occurs on terraces of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) in the Montane Ecoregion. Soils are Orthic and Eluviated Eutric Brunisols and vegetation is lodgepole pine/juniper/bearberry (C3), lodgepole pine/buffaloberry/showy aster (C6) and lodgepole pine/buffaloberry/twinflower (C19). The AT1 Ecosite is the more extensive of the two AT Ecosites.

The AT1 Ecosite is found on floors and lower benchland of broad valleys with a gentle gradient that accommodated large volumes of glacial meltwater. Extensive tracts are mapped in the Athabasca River valley from Jasper townsite to the Sunwapta River in Jasper. The AT1 Ecosite is the only AT Ecosite mapped in Banff. It is found in both the lower North Saskatchewan and lower Bow River valleys.

Geomorphology

The AT1 Ecosite occurs on terraces of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B). Some tracts retain an irregular channeled (Eroded modifier, C.S.S.C. 1978b) surface as evidence of the braided streams that formed them. The AT1 areas have generally remained stable, accumulating a thin, discontinuous veneer of altered, medium textured eolian material (Eolian material B). This veneer occurs sporadically in Jasper and is more common to the south. A thin veneer of calcareous, medium textured eolian material (Eolian material A) occurs in the Athabasca River valley downstream from Jasper townsite and locally near the east gate in the North Saskatchewan River valley.

Recent fluvial material (slope wash) occasionally mantles portions of the terraces abutting steeper slopes that are gullied. Present watercourses often form one boundary of, or bisect AT1 tracts.

The AT1 tracts are often mapped as having complex slopes. Within tracts, slopes between 1 and 15% are most common. Treads of the terraces make up a majority of the area, and have linear, gentle slopes. These contrast with the short steeper risers or scarps between terrace levels.

Irregular surfaces are also typical of tracts that have inclusions of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). These inclusions are of two kinds. They may be integral parts of the landform such as the esker near the Cascade Road trailhead in Banff over which the Lake Minnewanka Road is built. Secondly, they may be knolls of ice contact material, remnants of a former landscape surface that are incompletely planed smooth or buried in the genesis of the AT landform, such as those found in the vicinity of the junction of the David Thompson highway with the Icefields Parkway in Banff.

Soils

Soils of AT1 are Orthic and Eluviated Eutric Brunisols. The latter occur most frequently in association with Eolian material B. These soils are genetically similar, with taxanomic separation being based on the depth of the surface eluvial (Ae) horizon. Table 104 describes a pedon sampled near Two Jack Lake in Banff that illustrates soils of AT1. Color Plate 2 is a photograph of this pedon.

Table 104 Pedon (Alberta 1977 No. 132) description of an Eluviated Eutric Brunisol of the AT1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1970, SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: AT1.

LOCATION: MILITARY GRID REF. 11 UPG 330 7430; NTS MAP AREA 82O 4E.

CLIMATE: 1490 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS GOOD RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 11 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JD7114*VTN=C3*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), WEAKLY CALCAREOUS (1 TO 6% CACO3), EOLIAN; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND SANDY, EXTREMELY CALCAREOUS (>40% CACO3), GLACIOFLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: GLACIO FLUVIAL, TERRACED; SLOPE: 3% SIMPLE SLOPE OF CLASS 3 (2-5%), FACING WEST, SITE AT MIDDLE POSITION; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY.

SPECIAL NOTES: SSN=SC7052*APN=010-223*RLU=15*SSC=MOR*PCF=30R(3)SGR,2CB(4-5)SGR,1CB(6)*LFM=FOT*

LF: 4 TO 0 CM, RANGE 2 TO 6 CM; MATRIX MOIST 10YR 4/2; PLENTIFUL, MICRO AND FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 2 CM, RANGE 0 TO 8 CM; MATRIX MOIST 7.5YR 5.5/3, MATRIX DRY 7.5YR 7.5/2; SILT LOAM; MODERATE, COARSE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO ROOTS; COMMON, FINE, RANDOM PORES; WAVY, CLEAR HORIZON BOUNDARY.

BM: 2 TO 22 CM, RANGE 18 TO 22 CM; MATRIX MOIST 7.5YR 5/6; SILT LOAM; MODERATE, FINE, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MICRO AND FINE ROOTS; FEW, FINE, RANDOM PORES; WEAKLY CALCAREOUS; 10% GRAVELLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2CK1: 22 TO 42 CM, RANGE 15 TO 25 CM; MATRIX MOIST 10YR 4/2, EXPED MOIST 7.5YR 4/2; GRAVELLY LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; MODERATE, COARSE, SUBANGULAR BLOCKY SECONDARY STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, MICRO AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 40% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2CK2: 42 TO 65 CM, RANGE 10 TO 27 CM; MATRIX MOIST 10YR 5/2, EXPED MOIST 10YR 5/3; GRAVELLY LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; MODERATE, COARSE, SUBANGULAR BLOCKY SECONDARY STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, MICRO AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 40% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2CK3: 65 TO 99 CM; MATRIX MOIST 10YR 5/2; GRAVELLY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; FEW, FINE ROOTS; MODERATE EFFERVESCENCE; COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	5.8	42.50							
AE	5.6	1.60		11.5		8.3	2.5	0.1	0.3
BM	6.8		2.5						
2CK1	7.4		40.8						
2CK2	7.4		47.7						
2CK3	7.5		72.8						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	0.1		-.1	
2CK1				
2CK2				
2CK3				

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF															
AE					3	8	7	8	10	33		54	13	4	1.30
BM					3	6	6	6	9	30		51	19	7	1.50
2CK1					11	29	23	9	4	76		19	5	2	
2CK2					22	31	21	6	2	82		15	3	2	
2CK3	99	89	78	70	14	37	36	8	1	96		2	0	0	

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AE								
BM								
2CK1								
2CK2	0.0	0.0					12	06
2CK3	0.0	0.0					12	06

The variable depth (0-8 cm) of the Ae horizon indicates that this pedon falls on the taxonomic boundary between Orthic and Eluviated Eutric Brunisols. It has an eolian-glaciofluvial parent material disconformity in the solum. The lower portion of the B horizon has a low residual calcium carbonate content typical of soils of the Ecosite. The low extractable iron and aluminum values in the B horizon developed in the eolian material indicate a weak weathering environment. The gravelly coarse textures in the lower horizons are typical, though somewhat coarser than usual in the IICk3. Variable calcium carbonate content is depositional in the lower horizons.

Soils of AT1 are rapidly to well drained because of the pervious nature of the glaciofluvial materials and the low precipitation in the Montane. Seeps are very rare, occurring only occasionally at some landform breaks. Deep water tables are usually associated with AT1.

Turbic phases of AT1 soils occur sporadically throughout the landscape where windthrow of trees has disturbed the solum. Lithic phases are absent because of the thickness of the glaciofluvial material that usually also overlies other unconsolidated materials.

Vegetaton

The lodgepole pine/juniper/bearberry (C3), lodgepole pine/buffaloberry/showy aster (C6), and lodgepole pine/buffaloberry/twinflower (C19) v.t.s are dominant on AT1. The C3 v.t. is the most widely distributed, but any of these three may dominate a given tract. The C19 v.t. occurs most frequently close to the Lower Subalpine boundary, and C6 is dominant on all AT1 tracts in the North Saskatchewan River valley.

Most tracts of AT1 occur in accessible major valleys and have generally been influenced by fire within the past century. Thus, much of the AT1 vegetation is seral although some C3 stands appear to be mature. Table 105 describes a plot sampled at the same site as the pedon in Table 104 and illustrates the C3 v.t. on AT1. Plate 8 is a photograph of this plot area.

Though this plot is classified as an example of the C3 v.t., it has a lower cover of *Juniperus communis* and a higher cover of *calamagrostis rubescens* and *Elymus innovatus* than modal. The understory suggests elements of the Douglas fir/hairy wild rye (C1) v.t., an inclusion on AT1 tracts in isolated patches that have escaped intense fire for several hundred years. Some sites in side valleys of the lower Athabasca River valley in Jasper may have spruce forest.

Table 105 Stand (JD7114) illustrating the lodgepole pine / juniper / bearberry (C3) v.t. of the AT1 Ecosite.

TREE LAYER	
Picea engelmannii	.5
Pinus contorta	40
TALL SHRUB LAYER	
Picea engelmannii	.5
Pinus contorta	05
SHRUB LAYER	
Juniperus communis	01
Pinus contorta	.5
Rosa acicularis	.5
Shepherdia canadensis	01
Spiraea lucida	.5
Salix sp.	.5
HERB-DWARF SHRUB LAYER	
Achillea millefolium	.5
Antennaria racemosa	.5
Arctostaphylos uva-ursi	20
Arnica cordifolia	.5
Aster conspicuus	01
Calamagrostis rubescens	55
Calypso bulbosa	.5
Campanula rotundifolia	.5
Carex concinnoides	01
Elymus innovatus	25
Epilobium angustifolium	.5
Fragaria virginiana	.5
Gentiana propinqua	.5
Hedysarum sulphurescens	.5
Linnaea borealis	10
Oxytropis campestris	.5
Oxytropis deflexa	.5
Oxytropis splendens	.5
Penstemon confertus	.5
Pyrola secunda	.5
Pyrola virens	.5
Trifolium repens	.5
Vaccinium caespitosum	02
Zygadenus elegans	.5
BRYOID LAYER	
Cetraria ericetorum	.5
Cladonia gonecha	01
Cladonia phyllophora	01
Dicranum spp.	.5
Drepanocladus uncinatus	.5
Eurhynchium pulchellum	.5
Hylocomium splendens	01
Peltigera aphthosa	.5
Peltigera rufescens	
Pleurozium schreberi	.5
Pohlia nutans	05
Polytrichum juniperinum	.5
Stereocaulon tomentosum	.5
	.5
EPIPHYTES	
Alectoria sp.	
Letharia sp.	.5
Usnea sp.	.5
	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The AT1 Ecosite occurs on one of the most stable unconsolidated landforms in the parks. The valley floor position is remote from disturbance such as snow avalanching. The

AT1 Ecosite does not occur as a complex with Miscellaneous Landscapes. Tracts in the Athabasca River valley in the vicinity of Jasper Lake in Jasper, and towards the east gate in the North Sasktchewan River valley in Banff may have thin veneers of actively accumulating calcareous, medium textured eolian material (Eolian material A). Locally they may resemble Talbot 3 (TA3).

The dry condition of AT1 means that it is likely more susceptible to fire than other Ecosites. Tracts of AT1B show the effects of recent fire on vegetation in the North Saskatchewan River valley just above its confluence with the Howse River in Banff.

Tracts of AT1 are frequently disturbed by human activity, especially in the major accessible valleys. Borrow pits are common, usually along the transportation and utility corridors that traverse the gentler slopes of this Ecosite. The Jasper townsite and Whistlers campground are examples of development common on AT1 tracts.

Glaciofluvial terraces identical to AT1 may occur, but only locally, in tracts mapped as members of the Patricia (PT) Ecosection or Norquay 3 (NY3) Ecosite. The PT Ecosection concept is distinguished from the AT Ecosection concept by calcareous, medium textured till (Till C), while NY3 is distinguished by the calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). In the transition zone from Montane to Lower Subalpine, AT1 resembles and is mapped adjacent to its Lower Subalpine eqivalent, Bow Valley 1 (BV1). Fireside 1 (FR1) often adjoins and closely resembles AT1, but the former is found on calcareous, coarse, stratified fluvial material (Fluvial material B). The FR1 Ecosite often is mapped on fluvial fans that mantle the glaciofluvial material typical of the AT1 Ecosite, such as the fan of Johnston Creek in Banff. Vegetation differences that distinguish AT1 from AT3 are outlined in Table 103. In the Athabasca River valley below Jasper townsite, some AT1 tracts have patchy areas of junegrass-pasture sage-wild blue flax (H6), too small to be delineated as AT3.

AT3 - ATHABASCA 3 ECOSITE

Ecosite Concept

The AT3 Ecosite occurs on terraces of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) in the Montane Ecoregion. Orthic Eutric Brunisols are dominant soils, while a pattern of junegrass-pasture sage-wild blue flax (H6) with a lower percentage of lodgepole pine/juniper/bearberry (C3) is the prevalent vegetation.

The AT3 Ecosite is restricted to the Athabasca River valley floor and lower benchland in Jasper, between Jasper townsite and the Snake Indian River. It is the less extensive of the two AT Ecosites. The largest tract surrounds the Henry House area.

Geomorphology

The AT3 Ecosite occurs on terraces of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B). Much of the glaciofluvial material in this area of the Athabasca River valley varies from modal Glaciofluvial material B in two ways. It is lower in lime because of the extensive are of noncalcareous bedrock in the Athabasca drainage above Jasper townsite. Secondly, the bedding structures present, with their variable texture and coarse fragment content, indicate a gentler stream gradient with a slower aggradation rate than modal. These conditions are usually found some distance removed from the melting ice front.

The AT3 areas have generally remained stable, but evidence suggests a thin vener of calcareous, medium textured eolian material (Eolian material A) has recently accumulated. The lower coarse fragment content results in deposits that are more easily eroded than the more gravelly materials of AT1. Along the lower margins of tracts mapped as AT3 erosional scarps frequently abut fluvial Ecosites.

Some areas retain an irregular channeled (eroded) surface as evidence of the braided streams that formed them. Locally, slopes can be complex, but treads of the terraces with gentle linear slopes are so dominant in areal extent, that tracts are mapped with simple slope type. Slopes are less that 5% except on the few short, steep scarps between terrace levels.

Soils

Current additions of calcareous, medium textured eolian material to the soils of AT3 result in an overblown phase (C.S.S.C. 1978b) of Orthic Eutric Brunisols. A varied geomorphic history on this Ecosite can be inferred from the distribution and genesis of these soils. Evidence suggests that at some time in the past, weakly developed Eutric Brunisols, similar to those presently found on AT1 in the absence of eolian veneer, were dominant soils on AT3 tracts. This genesis was brought to an end by the deposition of calcareous, medium textured eolian material (Eolian material A). Lime leached from this material has recalcified the buried B horizons. Constant eolian additions have produced Ahk rather than eluvial A (Ae) horizons.

An overblown phase of an Orthic Eutric Brunisol, sampled near Henry House, is presented in

Table 106 and represents soils of AT3. This pedon may also be classified as Orthic Melanic Brunisol.

Table 106 Pedon (Alberta 1976 No. 70) description of an overblown phase of an Orthic Eutric Brunisol representing soil of the AT3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: AT3. SOIL PHASES: OVERBLOWN.

LOCATION: MILITARY GRID REF. 11 UNJ 2795 7223; NTS MAP AREA 83O 16E.

CLIMATE: 1820 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS MODERATE RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 15 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: *VTN=N6*.

SOIL SITE: PARENT MATERIAL 1: CHEMICAL AND PHYSICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), EOLIAN, UNDIFFERENTIATED OR UNDETERMINED; PARENT MATERIAL 2: CHEMICAL AND PHYSICAL WEATHERING, SANDY, MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), GLACIOFLUVIAL, UNDIFFERENTIATED OR UNDETERMINED; LANDFORM CLASSIFICATION: GLACIO FLUVIAL, TERRACED; SLOPE: 2% COMPLEX SLOPE OF CLASS 2 (0.5-2%), FACING LEVEL, SLIGHTLY MOUNDED MICROTOPOGRAPHY,150 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, SLOW SURFACE RUNOFF, SEEPAGE ABSENT; NONSTONY; NONROCKY.

SPECIAL NOTES: SSI=JT6027*APN=015-138*PCF=1GR(6-7)*2CK1-CACO3 PRECIPITATED ON BOTTOM OF COARSE FRAGMENT*LFH=EV/FGT*

AHK: 0 TO 12 CM, RANGE 10 TO 12 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/2, MATRIX MOIST 10YR 3/2; SANDY LOAM; VERY WEAK, VERY FINE TO FINE, GRANULAR STRUCTURE; NONSTICKY, LOOSE, NONPLASTIC CONSISTENCE; ABUNDANT, VERY FINE AND FINE, VERTICAL AND HORIZONTAL, EXPED ROOTS; COMMON, FINE, RANDOM PORES; STRONG EFFERVESCENCE; MODERATELY CALCAREOUS; SMOOTH, CLEAR HORIZON BOUNDARY; NEUTRAL 6.6-7.3 FIELD PH.

ACK: 12 TO 14 CM, RANGE 1 TO 3 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/3, MATRIX MOIST 10YR 4/3; SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; NONSTICKY, LOOSE, NONPLASTIC CONSISTENCE; ABUNDANT, VERY FINE AND FINE, VERTICAL ROOTS; FEW, FINE, RANDOM PORES; STRONG EFFERVESCENCE; SMOOTH, ABRUPT HORIZON BOUNDARY; NEUTRAL 6.6-7.3 FIELD PH.

2BMBK1: 14 TO 24 CM, RANGE 10 TO 12 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 4/4, MATRIX MOIST 5YR 4/4; LOAMY SAND; VERY WEAK, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; NONSTICKY, VERY FRIABLE, NONPLASTIC CONSISTENCE; PLENTIFUL, VERY FINE AND FINE, VERTICAL ROOTS; STRONG EFFERVESCENCE; WEAKLY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY; NEUTRAL 6.6-7.3 FIELD PH.

2BMBK2: 24 TO 29 CM, RANGE 4 TO 6 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/6; LOAMY SAND; STRUCTURELESS, MASSIVE STRUCTURE; NONSTICKY, VERY FRIABLE, NONPLASTIC CONSISTENCE; PLENTIFUL, VERY FINE AND FINE, VERTICAL ROOTS; STRONG EFFERVESCENCE; WEAKLY CALCAREOUS; SMOOTH, CLEAR HORIZON BOUNDARY; NEUTRAL 6.6-7.3 FIELD PH.

2BCK: 29 TO 46 CM, RANGE 17 TO 19 CM; HORIZON DRY; MATRIX MOIST 10YR 5/6; LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; NONSTICKY, VERY FRIABLE, NONPLASTIC CONSISTENCE; PLENTIFUL, VERY FINE AND FINE, VERTICAL ROOTS; STRONG EFFERVESCENCE; WEAKLY CALCAREOUS; FEW, FINE, OBLONG, SPOTTED SECONDARY CARBONATES WITH LOOSE , AND LOOSE CONSISTENCE, 10R 7/3; SMOOTH, ABRUPT HORIZON BOUNDARY; NEUTRAL 6.6-7.3 FIELD PH.

2CK1: 46 TO 52 CM, RANGE 5 TO 7 CM; HORIZON DRY; MATRIX MOIST 10YR 5/3; LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; NONSTICKY, VERY FRIABLE, NONPLASTIC CONSISTENCE; FEW, VERY FINE AND FINE, VERTICAL ROOTS; STRONG EFFERVESCENCE; MODERATELY CALCAREOUS; COMMON, MEDIUM, NODULAR SECONDARY CARBONATES WITH VERY FRIABLE , AND SOFT CONSISTENCE, 10R 7/3; SMOOTH, ABRUPT HORIZON BOUNDARY; NEUTRAL 6.6-7.3 FIELD PH.

2CK2: 52 TO 75 CM; HORIZON DRY; MATRIX MOIST 10YR 6/3, MATRIX MOIST 10YR 4/2; SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; NONSTICKY, LOOSE, NONPLASTIC CONSISTENCE; STRONG EFFERVESCENCE; MODERATELY CALCAREOUS; SMOOTH, CLEAR HORIZON BOUNDARY; NEUTRAL 6.6-7.3 FIELD PH.

2CK3: 75 TO 95 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/3, MATRIX MOIST 10YR 4/2; SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; NONSTICKY, LOOSE CONSISTENCE; STRONG EFFERVESCENCE; MODERATELY CALCAREOUS; NEUTRAL 6.6-7.3 FIELD PH.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
AHK	7.5	2.90	9.0
ACK			
2BMBK1	7.6	1.30	3.8
2BMBK2	7.7	0.80	2.6
2BCK	7.6		3.8
2CK1	7.8		9.4
2CK2	7.8		10.2
2CK3	7.7		11.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2
AHK				
ACK				
2BMBK1	0.0		-.1	
2BMBK2	0.0		-.1	
2BCK				
2CK1				
2CK2				
2CK3				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
AHK					1	25	21	5	8	60		37	3	2
ACK														
2BMBK1					2	33	32	7	4	78		19	3	2
2BMBK2					2	37	32	5	3	79		19	2	1
2BCK					1	28	42	9	3	83		13	4	1
2CK1					2	33	34	7	3	81		16	3	1
2CK2	99	96	90	83	2	36	39	6	3	86		12	2	1
2CK3	99	99	97	94	5	84	38	3	2	94		5	1	1

The surface veneer of this pedon is lower in silt than is modal for Eolian material A, but another sample of this same veneer taken within 500 m was 81% silt. The infusion of secondry carbonate into the buried B horizons is well demonstrated by the calcium carbonate equivalent values, as is the accumulation of organic material in the Ahk horizon. The iron and aluminum data indicate any or all of 1) parent material low in primary minerals, 2) a short duration of weathering, or 3) a weak weathering environment. The summer temperature of this pedon is warmer than those of most other Eosites in the parks.

Soils of AT3 are rapidly drained because of the low precipitation in this area of the Athabasca River valley and the pervious nature of the glaciofluvial material. Deep water tables are associated with AT3.

Vegetation

The vegetation of AT3 is a pattern dominated by junegrass-pasture sage-wild blue flax (H6) with a lesser abundance of lodgepole pine/juniper/bearberry (C3). As all AT3 tracts occur in the Athabasca River valley in the drier area below Jasper townsite, fire has had a major effect on these tracts. The addition of calcareous, medium textured eolian material (Eolian material A) is also a factor contributing to the vegetation assemblage. Table 107 describes a plot of the H6 v.t. sampled at the same site as the pedon described in Table 106. Plate 72 shows this vegetation plot area. This plot has modal characteristics of the H6 v.t.

Table 107 Stand (IC5003) illustrating the junegrass-pasture sage-wild blue flax (H6) v.t. of the AT3 Ecosite.

	HERB-DWARF SHRUB LAYER
Agropyron dasystachyum	.5
Androsace septentrionalis	.5
Anemone multifida	.5
Antennaria nitida	05
Artemisia campestris	.5
Artemisia frigida	01
Bromus pumpellianus	.5
Koeleria cristata	05
Linum lewisii	.5
Senecio cymbalarioides	.5
Potentilla sp.	.5
	BRYOID LAYER
Barbula acuta	.5
Bryum spp.	.5
Encalypta vulgaris	.5
Fulgensia fulgens	.5
Physconia muscigena	.5
Psora decipiens	.5
Squamarina lentigera	.5
Tortula ruralis	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Local areas on most stable positions may have the Douglas fir/hairy wild rye (C1) v.t., for instance, in the vicinity of Lake Edith. White spruce/juniper/bearberry (O17) occurs in local areas wher eolian material is more actively accumulating, such as close to the floodplain of the Athabasca River.

The pattern of grassland and forest vegetation is only weakly reflected in the soils. Soil morphology varied slightly between the vegetation settings, but soil classification remains constant. Eolian veneers, enriched in organic material (dark colored Ahk or ACk horizons), are thicker and more strongly expressed in areas of grassland, but also occur throughout the forested portions. Buried Brunisolic profiles occur throughout AT3 tracts, but horizons are most strongly expressed under the thinner eolian veneer of the forested areas.

Discussion

The history and future of AT3 tracts can be inferred from the combined evidence of geomorphology, soils and vegetation. Because of the infusion of carbonate, evident in the B horizon of the buried Brunisolic profiles, these Brunisols formed prior to the deposition of the eolian material. They probably developed under vegetation similar to forests on the present AT1 Ecosite, as the morphology and chemical characteristics are similar. Next, some agent or combination of agents, such as drier climatic conditions and fire, removed this forest for an extended period, leaving these areas open to an episode of eolian deposition. During this eolian accretion, grassland vegetation was probably dominant, with conditions similar to those presently found on the Talbot 2 (TA2) Ecosite. Soil morphology in the eolian veneer is similar, in both Ecosites, with grassland organic material accumulation in the surface horizons. Presently, on AT3 tracts, there is a tension between forest and grassland, with the former encroaching on the latter. The dry, warm conditions and eolian aggradation necessary for the maintenance of the junegrass-pasture sage-wild blue flax (H6) v.t. (cf TA2 Ecosite) are present, but not rigorous enough to check forest encroachment without the aid of concomitant fires. In the absence of fire and under present conditions, AT3 is expected to become identical to AT1 as it likely was in its earlier history. This evolution has occurred on forested portions of AT3, where eolian veneers and soils retain vestiges of grassland vegetation influence (dark colored Ahk or ACk horizons) despite being completely forested, except for small, local patches of grassland.

The AT3 Ecosite occurs on one of the most stable landforms in the parks. Except for the accumulation of a very thin veneer of eolian material, the level valley floor position is not subject to any geomorphic disturbance.

The AT3 does not occur as complexes with Miscellaneous Landscapes, or with Ecosite modifiers.

Because of their accessible location and gently sloping landform, most AT3 tracts are presently disturbed by transportation corridors. In the Henry House vicinity, the Canadian National Railway, the Yellowhead Highway and the Jasper airstrip all occupy part of the same AT3 tract. Of the other tracts, all but one have secondary roads traversing them.

Talbot 2 (TA2) differs from AT3 because the rate of eolian aggradation and depth of eolian material is greater than AT3. Also TA2 is found on steep southerly aspects. Hillsdale 4 (HD4) has similar eolian veneer, soils and vegetation but occurs on calcareous, coarse, stratified fluvial material (Fluvial material B). The vegetation pattern that separates AT3 from AT1 is outlined in Table 103.

AZ - AZURE ECOSECTION

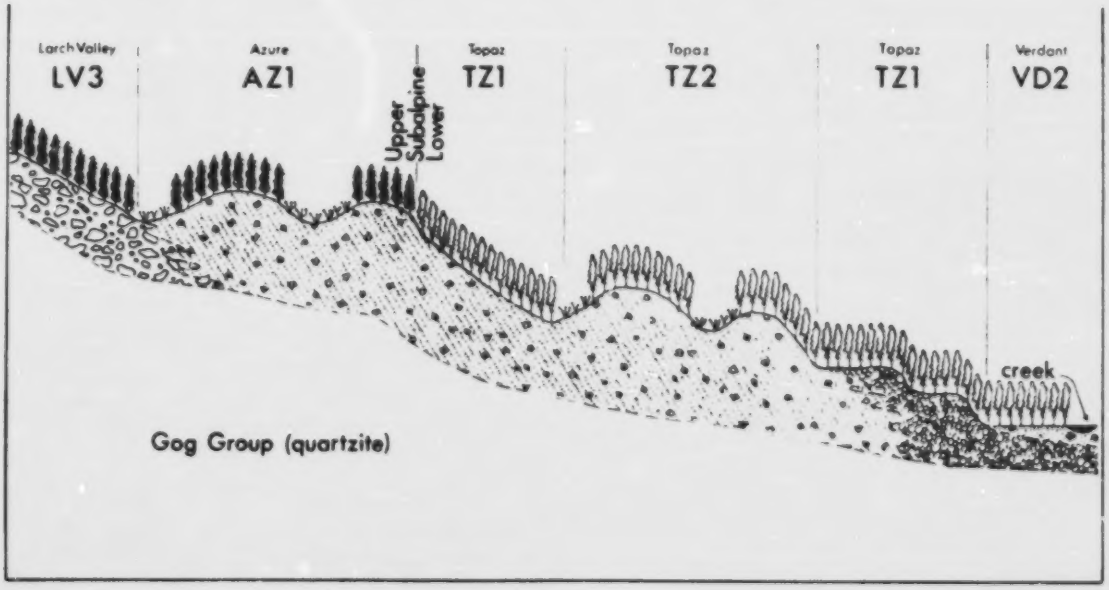
The Azure Ecosection is found on noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A) in the Upper Subalpine portion of the Subalpine Ecoregion. Complex slopes result in a dry-wet pattern of soils and vegetation. Dystric Brunisols and Engelmann spruce-subalpine fir open forest occupy upland positions, while poorer drainage in depressions produces Gleysolic and Organic soils with wet shrub thickets and wet herb meadows.

The AZ Ecosection is all but restricted to the Main Ranges where noncalcareous bedrock source areas, especially Gog Group quartzites, are extensive enough that little or no limestone is incorporated into the ice contact stratified material. The AZ Ecosection is quite limited in extent and distribution in Banff and southern Jasper. In northern Jasper, the headwaters of Blue Creek near Azure Lake and the Miette Pass vicinity contain the most extensive tracts. Only one AZ Ecosite (AZ1) is recogized (Table 108). Fig. 30 shows AZ distribution in a schematic landscape.

Table 108 General features of the Azure 1 (AZ1) Ecosite.

Ecosite	Landform	Soils	Vegetation
AZ1	Ice Contact Stratified Drift A; hummocky, ridged	Dry^{70}: Dystric Brunisol	Dry^{70}:Engelmann spruce-subalpine fir open forest
		Wet^{30}: Gleysolic > Organic	Wet^{30}:wet shrub thicket, wet herb meadow

Figure 30 Landscape schematic showing the relationship of the Azure 1 (AZ1) and Topaz 1 (TZ1) Ecosites to other Ecosites.



AZ1 - AZURE 1 ECOSITE

Ecosite Concept

The AZ1 Ecosite is comprised of hummocky and ridged noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A) in the Upper Subalpine portion of the Subalpine Ecoregion. This landform produces a dry-wet landscape pattern dominated by upland with Eluviated Dystric Brunisols and Engelmann spruce-subalpine fir/heather (O10). The poorly drained soils of depressions are Rego Gleysols more frequently than Terric Mesisols with willow/cinquefoil (S8) and mountain marigold-globeflower (H9) v.t.s.

The AZ1 Ecosite is a valley floor and lower slopes Ecosite of broad valleys with gentle grades along their length and surrounded by noncalcareous bedrock. These conditions are found, though infrequently, in the Main Ranges, often in association with Gog Group (quartzite) bedrock.

Geomorphology

Landforms of the AZ1 Ecosites are composed of noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A) with hummocky and ridged surface expression. Slopes are usually complex and range from 5 to 45%. Glaciofluvial ice contact processes appear to have been dominant in the creation of these landforms, as indicated by coarse, stratified materials and features such as ice marginal channels and eskers. Dominant quartzite lithology also contributes to coarseness of textures.

Some of the depressional localities occupied by small, often intermittent, streams have been modified by the addition of fluvial veneers. Where water is ponded, small, shallow, horizontal fens have developed.

In the Miette Pass area in Jasper tracts of AZ1 have a discontinuous, noncalcareous, fine textured, glaciolacustrine veneer over the ice contact material.

Tracts of AZ1 in Banff have a thin surface veneer of altered, medium textured eolian material (Eolian material B).

Soils

A pattern of soils related to drainage, Plate 87, is produced by the complex slopes of the landform. Drier uplands make up approximately 70% of any tract and are dominated by rapidly to well drained Eluviated Dystric Brunisols. These soils show morphological evidence of comparatively strong development such as thick Ae horizons and strongly colored, thick B horizons. A pedon, sampled in upper Blue Creek, illustrative of the upland soils of AZ1, is described in Table 109 and shown in Color Plate 3.

The weak cementation (duric tendency) typical of coarse textured, noncalcareous soils in Banff and Jasper is present in the lower B horizon of this pedon.

The kind of soils found in wet (imperfectly to very poorly drained) depressions between ridges and hummocks depends on depth to the water table and landform modification. Rego Gleysols are the most common soils and are found with surface fluvial modification. These soils often have organic surface horizons that may be up to 40 cm thick and form a pattern in the depressions with the less frequently encountered Terric Mesisols on fens.

Other wet soils less frequently encountered in the depressions are Gleyed Dystric Brunisols found in wet positions where the glacial materials are not modified by fluvial or organic landform processes. These areas may have any or all of the genetically similar Gleyed Dystric Brunisols, Orthic Gleysols or gleyed Podzols, especially in Banff where altered, medium textured eolian material (Eolian material B) is present.

Table 109 Pedon (Alberta 1979 No. 38) description of an Eluviated Dystric Brunisol of dry upland segments of the AZ1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF TP; YEAR 1976, SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: AZ1.

LOCATION: MILITARY GRID REF. 11 ULX 7185 8130; NTS MAP AREA 83E 7H.

CLIMATE: 1980 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 13 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: VPH=LC9164=VTH=?=.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND SANDY, EXTREMELY TO STRONGLY ACIDIC (PH.S.S), GLACIOFLUVIAL, QUARTZITE; LANDFORM CLASSIFICATION: GLACIO FLUVIAL, COBBLY, HUMMOCKY; SLOPE: 10% COMPLEX SLOPE OF CLASS 5 (10-15%), FACING SOUTHWEST, SLIGHTLY ROUNDED MICROTOPOGRAPHY,10 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; EXCEEDINGLY STONY; NONROCKY.

SPECIAL NOTES: SSH=SC9658=APH=015-125=PCF=3GR,1CB(1-2)4GR,2CB(3-4)1GR(5)4GR,2CB(6)=BC HORIZON SAMPLED FROM 88-93CM=DATE=AUG 24,1979=

AE1: 0 TO 7 CM, RANGE 5 TO 10 CM; MATRIX MOIST 7.5YR 7/2; LOAMY SAND; WE/K, MEDIUM, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MICRO ROOTS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

AE2: 7 TO 30 CM, RANGE 15 TO 33 CM; MATRIX DRY 10YR 8/2; LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; FEW, VERY FINE ROOTS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

A+B: 30 TO 50 CM, RANGE 7 TO 25 CM; MATRIX MOIST 7.5YR 6/6, MATRIX MOIST 7.5YR 5/8; LOAMY SAND; MODERATE, COARSE, PLATY STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BMC: 50 TO 80 CM, RANGE 25 TO 50 CM; MATRIX MOIST 7.5YR 5/6, MATRIX MOIST 7.5YR 6/6; LOAMY SAND; STRUCTURELESS, MASSIVE STRUCTURE; VERY FIRM CONSISTENCE; STRONGLY CEMENTEDBY HUMUS-ALUMINUM, CONTINUOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

BC: 80 TO 125 CM; MATRIX MOIST 10YR 7/6; LOAMY SAND; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; STRUCTURELESS SECONDARY STRUCTURE; FIRM CONSISTENCE; WEAKLY CEMENTED; WAVY, CLEAR HORIZON BOUNDARY.

C: 125 TO 135 CM; MATRIX MOIST 10YR 6/6; LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
AE1	3.9	0.50	3.9		0.5	0.0	0.0	<.1
AE2	4.5	0.40	1.0		0.1	0.0	<.1	<.1
A+B	4.5	0.70	1.5		0.1	0.0	0.0	<.1
BMC	5.0	0.60	1.3		0.3	0.0	0.0	<.1
BC	4.6	0.10	0.4		0.0	0.0	0.0	<.1
C	4.8	0.10	0.6		0.1	0.0	0.0	<.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2
AE1				
AE2				
A+B				
BMC	0.1		<.1	
BC				
C				

PHYSICAL DATA (SURVEY)

HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS % PASSING V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	80-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
AE1					4	10	22	32	10	78		19	3		
AE2					4	11	26	33	11	85		11	4		
A+B					3	8	26	32	14	83		16	1		
BMC					2	8	22	32	11	75		23	2		1.90
BC					1	1	4	23	25	54		44	0		1.70
C		99	81	65	59	5	12	24	33	9	83		14	1	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AE1	14.9		3.2										
AE2													
A+B	11.3		0.9										
BMC	11.7		1.1										
BC	21.8		0.7										
C									0.0	0.0		12	07

Vegetation

A pattern of vegetation types related to drainage variation caused by complex slopes and depth to water table is found on AZ1. Drier uplands, approximately 70% of any tract, are predominantly Engelmann spruce-subalpine fir/heather (O10) v.t.. A plot from upper Blue Creek < 1 km from the pedon described in Table 109 illustrates the O10 v.t. of AZ1 in Table 110.

Table 110 Stand (JE9043) illustrating the Engelmann spruce-subalpine fir / heather (O10) v.t. of dry upland segments of the AZ1 Ecosite.

TREE LAYER	
Abies lasiocarpa	02
Picea engelmannii	05
TALL SHRUB LAYER	
Abies lasiocarpa	07
Picea engelmannii	03
SHRUB LAYER	
Abies lasiocarpa	13
Betula glandulosa	10
Picea engelmannii	02
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	.5
Cassiope mertensiana	15
Empetrum nigrum	08
Phyllodoce empetriformis	05
Picea engelmannii	.5
Pyrola secunda	.5
Vaccinium caespitosum	02
Selaginella rupestris	.5
BRYOID LAYER	
Cetraria ericetorum	.5
Cetraria islandica	02
Cetraria laevigata	.5
Cladonia mitis	02
Cladonia bellidiflora	01
Cladonia gracilis	02
Cladonia pleurota	.5
Cladonia uncialis	02
Dicranum brevifolium	01
Dicranum scoparium	01
Lophozia floerkii	.5
Lecidea granulosa	.5
Lepraria neglecta	.5
Peltigera rufescens	.5
Polytrichum juniperinum	.5
Rhizocarpon geographicum	.5
Rhytidiadelphus spp.	.5
Umbilicaria deusta	.5
Umbilicaria hyperborea	01
Stereocaulon spp.	05
Barbilophozia lycopodioides	.5
EPIPHYTES	
Cetraria pinastri	.5
Letharia vulpina	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5
Alectoria spp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

This plot differs from modal O10 because of the high cover of both *Betula glandulosa* and lichens. These conditions, however, are typical of the O10 v.t. on AZ1. The variation especially the higher lichen cover, is attributable to more xeric and acidic surface conditions through rapid surface drainage on the coarse textured, noncalcareous material. Other v.t.s on upland portions of AZ1 include Engelmann spruce-subalpine fir/heather/feathermoss (C34) and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21). Engelmann spruce-subalpine fir/grouseberry (C15) is common on AZ1 in Banff and is the dominant v.t. of the tract near Haiduk Lake. Vegetation in the depressions on AZ1 depends strongly on the hydrologic conditions as influenced by the landform. Ridged landforms often have a wet, fluvial modified veneer in the lower positions, and willow/cinquefoil (S8) is more frequent than mountain marigold-globeflower (H9). Depressions in hummocky areas, or those with standing shallow water, are less common and may have H9, cottongrass/moss (H10), or water sedge-beaked sedge (H11), especially in association with organic soil and landform. Engelmann spruce-subalpine fir/valerian-fleabane (O9) occurs where open forest is established in wet portions of AZ1.

Discussion

Dry portions of the AZ1 Ecosite are quite simple and uniform taxonomically in landform, soil and vegetation. The subdominant, wet depressions are more complex, and except for their limited areal extent would be classified as Ecosites within either the Sphinx (SX) or Num-Ti-Jah (NT) Ecosections.

Upland positions may resemble closely the Larch Valley Ecosites LV2 and LV3 but these Ecosites are found on noncalcareous, coarse textured till (Till A). Topaz 2 (TZ2) has a similar dry-wet pattern and like AZ1 is found on noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A), but is a Lower Subalpine Ecosite. Both LV and TZ tracts are frequently mapped adjacent to AZ1 on the landscape.

Nigel 1 (NG1) is distinguished because it occurs on calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) and does not have a dry-wet pattern.

The AZ1 tract at Palliser Pass in extreme southern Banff is interpreted to occur in association with middle Paleozoic, quartz sandstone bedrock lithology rather than Gog Group quartzite. Vegetation on this tract has been significantly modified by fire.

BK - BAKER CREEK ECOSECTION

The Baker Creek (BK) Ecosection encompasses ridged and hummocky glacial landforms consisting of calcareous, medium textured till (Till C) or calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) throughout the Lower Subalpine portion of the Subalpine Ecoregion of Banff and Jasper. Its complex topography forms a compound landscape comprised of about 70% dry (well drained, mesic) upland segments and 30% wet (poorly to very poorly drained, hygric, to hydric) depressions between ridges and hummocks. Baker Creek (BK) Ecosites occur most often on the benchland of broad river valley floors, less often on the floors of narrower valleys and on lower valley wall slopes.

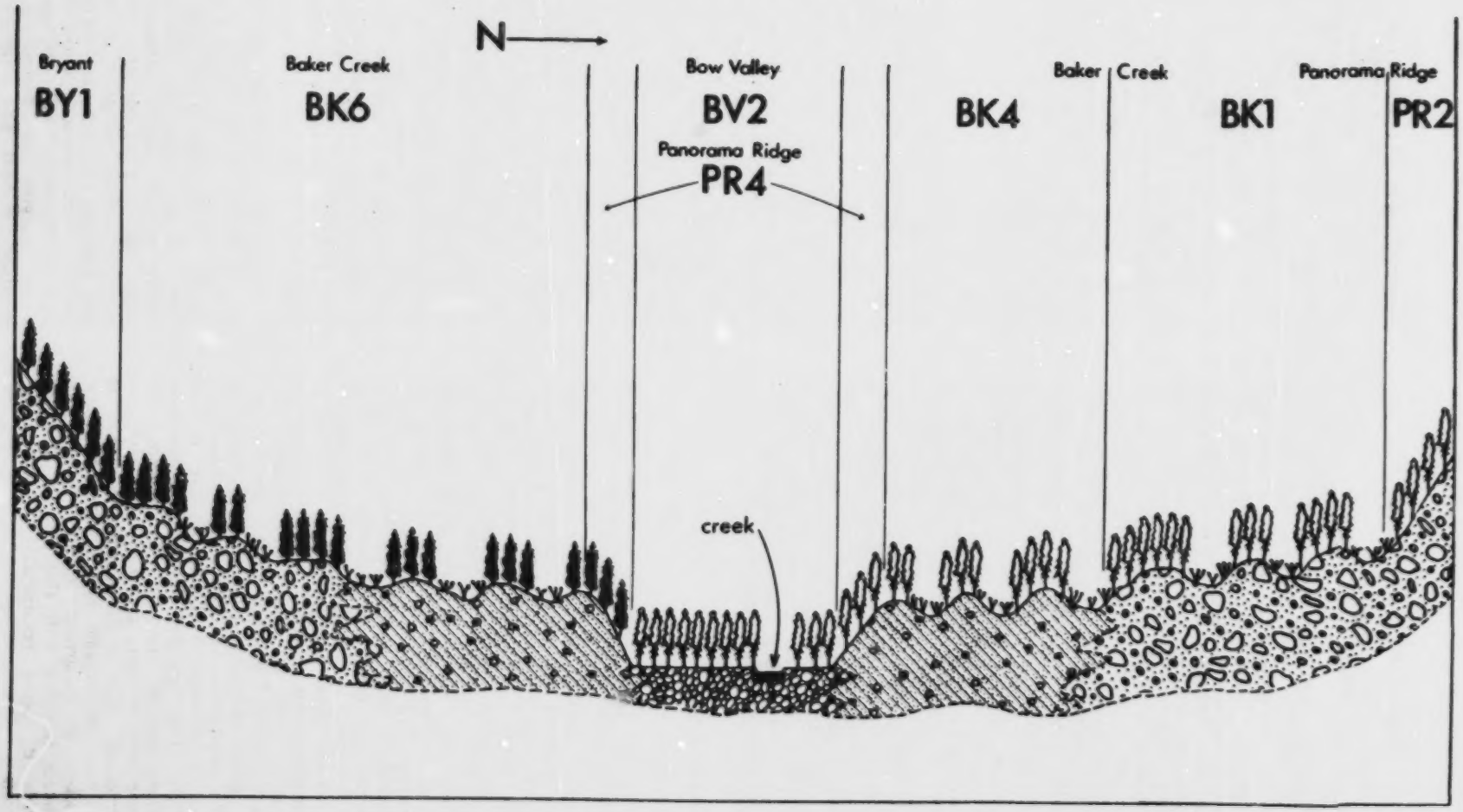
Upland segments are dominated by Eutric Brunisols that frequently exhibit luvisolic tendencies associated with weathering of calcareous glacial deposits under well drained, mesic conditions within the Lower Subalpine. Brunisolic Gray Luvisols are usually the subdominant soils. The dominant vegetation of upland segments, lodgepole pine or Engelmann spruce-subalpine fir forest, reflects complex fire histories. Pedogenically related Gleysolic and Organic soils occur on the wetland segments usually under wet spruce open forest, wet shrubby meadow, and/or birch fen. These depressional areas are often small closed basins in which seepage and surface waters accumulate. Shallow ponds often occur, especially on the BK1 and BK4 Ecosites. Some of the depressions have drainage outlets to nearby streams.

Genetic material differences and pine versus spruce dominated upland segments differentiate the three Baker Creek (BK) Ecosites as outlined in Table 111. Fig. 31 shows, schematically, the relative positions of the BK Ecosites and a few other Lower Subalpine Ecosites. Rarely do tracts of BK1, BK4 and BK6 adjoin as shown. Upland segments of BK1, BK4 and BK6 are similar to the Panorama Ridge 2 (PR2), Panorama Ridge 6 (PR6) and Bryant 2/Bryant 4 (BY2/BY4) Ecosites, respectively. Wetland segments resemble the Consolation Valley 1 (CV1), Hector 1 (HC1) and Hector 4 (HC4) Ecosites.

Table 111 General features of the Baker Creek (BK) Ecosites.

Ecosite	Landform	Soils	Vegetation
BK1	Till C; blanket, hummocky, ridged	Dry^{70}: Brunisolic > Luvisolic Wet^{30}: Gleysolic, Organic	Dry^{70}: lodgepole pine forest Wet^{30}: wet spruce open forest, wet shrubby meadow, birch fen
BK4	Ice Contact Stratified Drift B; blanket, hummocky, ridged	Dry^{70}: Brunisolic > Luvisolic Wet^{30}: Gleysolic, Organic	Dry^{70}: lodgepole pine forest Wet^{30}: wet spruce open forest, wet shrubby meadow, birch fen
BK6	Till C and Ice Contact Stratified Drift B; blanket, hummocky, ridged	Dry^{70}: Brunisolic Wet^{30}: Gleysolic, Organic	Dry^{70}: Engelmann spruce-subalpine fir forest Wet^{30}: wet spruce open forest, wet shrubby meadow, birch fen

Figure 31 Landscape schematic showing relative positions of the Baker Creek (BK) Ecosites and a few other Lower Subalpine Ecosites.



BK1 - BAKER CREEK 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, BK1, occurs on hummocky or ridged morainal landforms consisting of calcareous, medium textured till (Till C). Landform surface expression may be of depositional origin or controlled by underlying bedrock. Its complex topography forms a compound landscape comprised of about 70% dry (well drained, mesic) upland segments and 30% wet (poorly to very poorly drained, hygric to hydric) depressions between ridges and hummocks. Upland segments are characterized by a soil pattern in which Eluviated Eutric Brunisols are dominant, Orthic Eutric Brunisols and Brunisolic Gray Luvisols are subdominant. Luvisolic tendencies are common in the Brunisolic soils. Vegetation of upland segments is dominated by the lodgepole pine/buffaloberry/grouseberry (C18) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s. Wet depressional segments contain pedogenically related wet soils best represented by the Rego Gleysol and Terric Mesisol Subgroups. Associated wet vegetation usually includes the spruce/Labrador tea/brown moss (O11), dwarf birch-shrubby cinquefoil-willow/brown moss (S1), and/or dwarf birch-shrubby cinquefoil/needlerush (S3) v.t.s, with S1 being most abundant.

Geomorphology

The BK1 Ecosite is typified by morainal landforms consisting of calcareous, medium textured till (Till C). Surficial veneers of altered, medium textured eolian material (Eolian material B) occur extensively on BK1 tracts located in western Banff and southwestern Jasper, sporadically elsewhere. Depressional segments are usually thinly mantled by peat derived primarily from sedges and brown mosses (eg. *Tomenthypnum nitens* and *Aulacomnium palustre*). This fen peat, rarely exceeding 1.2 m in thickness, is mainly moderately decomposed but fibric and humic layers also occur. Occasionally wood fragments may be found. Where the peat is >40 cm thick, the landform is classified as horizontal fen (C.S.S.C. 1978b) recognizing that in some localities, fen vegetation has been succeeded by open forest. The fen peat is underlain, within the control section, by till, occasionally by calcareous, coarse, stratified fluvial material (Fluvial material B) and altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) veneers. In some sites, volcanic ash material is well preserved in eolian or fluviolacustrine veneers at or near the organic layer's lower boundary. Pockets of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) occur occasionally in some BK1 tracts.

Topographically, the BK1 Ecosite displays a series of subparallel or parallel ridges or irregularly distributed knolls (hummocks) separated by gently sloping depressions. Slopes commonly range from 5 to 30% although a few BK1 tracts with slopes ranging to 45% occur. Depressional segments, usually with slopes <5%, are generally concave and bowl shaped with subtle margins. The ridged and hummocky surface expressions may reflect underlying bedrock surfaces or be of depositional origin. Fluted ground moraine is an outstanding example of depositional ridged moraine (e.g. Bow River valley near Baker Creek, Plate 84). BK1 tracts on failed till slopes occur infrequently. Morainal veneers occur locally on some ridge and hummock crests but dominate on the few BK1X tracts mapped. Bedrock outcrops are not common except on BK1+R tracts.

Soils

Soils of the BK1 Ecosite are distributed in a pattern governed by drainage conditions. Soils of the well drained, upland segments are distributed in a pattern reflecting the thickness of the eluvial (Ae) horizon and the degree of luvisolic development. Eluviated Eutric Brunisols are dominant, Orthic Eutric Brunisols and Brunisolic Gray Luvisols subdominant. These soils have weak textural B horizons, some with sufficient pedogenic clay film development to be Bt horizons, occurring at or slightly below the till surface. Iron, aluminum and humus enriched Bm horizons developed in the altered, medium textured eolian (Eolian material B) veneers may occur above the textural B horizons. Orthic Gray Luvisols occur in minor amounts. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly expressed in the absence of altered, medium textured eolian material. In some localities, surface erosion inhibits Ae development. Lithic soils are common only on BK1X tracts. Gleyed Eutric Brunisols, Gleyed Eluviated Eutric Brunisols, Gleyed Brunisolic Gray Luvisols and Gleyed Gray Luvisols often occur in narrow transitional belts surrounding wet depressions. A pedon illustrating Brunisolic Gray Luvisols of upland segments of the BK1 Ecosite is described in Table 112 and shown on Color Plate 4.

A variety of pedogenically related soils occur on the poorly to very poorly drained, depressional segments of the BK1 Ecosite. These are best represented by the Rego Gleysol and Terric Mesisol Subgroups. Mineral layers are usually strongly gleyed reflecting high water tables and long periods of saturation; conditions that inhibit pedogenic horizonation. Orthic Gleysols are important accessory soils in localities with shorter periods of saturation such as depressions with drainage outlets and along margins of depressions. Favorable moisture, nutrient and vegetation conditions

have resulted in the accumulation of varying thicknesses of fen peat on the depressional soils. Terric Mesisols occur where the peat is >40 cm thick. Other Organic soils with subdominant humic or fibric layers, gleyed Podzols, gleyed Regosols and Humic Gleysols occur occasionally. A pedon illustrating Rego Gleysols of wet depressional segments of the BK1 Ecosite is described in Table 113.

Table 112 Pedon (Alberta 1975 No. 350) description of Brunisolic Gray Luvisol of dry upland segments of the BK1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: BRUNISOLIC GRAY LUVISOL. SOIL MAP UNIT: NOTATION: BK1.

LOCATION: MILITARY GRID REF. 11 UNG 5940 9520; NTS MAP AREA 82N 8E.

CLIMATE: 1550 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS GOOD RELEVANCE TO THE SOIL SITE.

VEGETATION: KEY SPECIES LISTING: 1 1550. VPN=JD4094*VTN=C*18*.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), EOLIAN; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), MORAINAL (TILL), SEDIMENTARY; LANDFORM CLASSIFICATION: MORAINAL, RIDGED; SLOPE: 5% COMPLEX SLOPE OF CLASS 4 (4-9%), FACING SOUTHWEST, SITE AT CREST POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,50 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; HUMUS-FORM: MOR.

SPECIAL NOTES: SSN=DA4083*APN=443-9*PCF=1GR*CB(2)2GR*CB(3)3GR,1CB(4-5)3GR,2CB(6-7)*ISSS CORRAL CREEK SITE*INFILTRATION RATE=5CM/HR*PERCOLATION RATE=300MIN/10CM*

LF: 3 TO 0 CM, RANGE 3 TO 4 CM; ABUNDANT, MEDIUM AND COARSE, RANDOM ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE1: 0 TO 2 CM, RANGE 0 TO 5 CM; EXPED DRY 10YR 7/1; SILT LOAM; WEAK, FINE, PLATY STRUCTURE; FRIABLE CONSISTENCE; ABUNDANT, MEDIUM AND COARSE, RANDOM ROOTS; COMMON, VERY FINE, HORIZONTAL AND OBLIQUE, INPED PORES; BROKEN, ABRUPT HORIZON BOUNDARY.

BM: 2 TO 12 CM, RANGE 7 TO 12 CM; EXPED DRY 10YR 6/4; SILT LOAM; STRUCTURELESS AND VERY WEAK, VERY FINE, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE AND FRIABLE CONSISTENCE; FEW AND PLENTIFUL, VERY FINE AND FINE, RANDOM ROOTS; FEW, VERY FINE PORES; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE2: 12 TO 17 CM, RANGE 3 TO 16 CM; CRUSHED DRY 10YR 7.5/2; SILT LOAM; WEAK, FINE AND MEDIUM, PLATY STRUCTURE; WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE; FRIABLE AND FIRM CONSISTENCE; FEW, VERY FINE, RANDOM ROOTS; COMMON, VERY FINE AND FINE PORES; FEW, THIN CLAY FILMS ON PED FACES-UNSPECIFIED; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

2BT: 17 TO 31 CM, RANGE 11 TO 15 CM; CRUSHED DRY 10YR 6/3; CLAY LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE AND FIRM CONSISTENCE; FEW, MICRO ROOTS; FEW, VERY FINE, RANDOM, INPED PORES; MANY, THIN CLAY FILMS ON PED FACES-UNSPECIFIED, 7.5YR 5/4; GRAVELLY AND COBBLY COARSE FRAGMENTS; SMOOTH AND WAVY, CLEAR HORIZON BOUNDARY.

2CK1: 31 TO 40 CM, RANGE 8 TO 10 CM; CRUSHED DRY 10YR 7/2; LOAM; MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FIRM CONSISTENCE; FEW, MICRO ROOTS; COMMON, VERY FINE PORES; FEW, VERY THIN CLAY FILMS ON PED FACES-UNSPECIFIED; MODERATE EFFERVESCENCE; VERY STRONGLY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2CK2: 40 TO 75 CM; MATRIX MOIST 2.5Y 5.5/4; LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FIRM CONSISTENCE; VERY FI'' ROOTS; VERY FEW PORES; MODERATE EFFERVESCENCE; VERY STRONGLY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	PH 2	ORG C (%)	TOTAL N (%)	CALC CAPB EQU.%	EXCHANGEABLE CATIONS-NEUTRAL SALT(ME/100G) CA	MG	AL	C.E.C. (ME/100G) BUFF.	PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.9	4.9	37.10	0.90		34.5	6.7	0.3	58.5	43.8	36.6	7.4	0.1	3.1
AE1	4.6	5.3	1.80	0.10		4.2	1.1		8.0		4.4	1.5	0.1	0.1
BM	5.5	6.2	1.70	0.10		3.8	1.5		12.2	5.7	4.3	1.4	0.1	0.1
AE2	5.5	6.1	0.50	<.10		8.6	3.2		5.1	5.5	4.2	1.7	<.1	0.1
2BT	6.4	7.0	0.40	0.10	1.5				9.2	11.9	9.8	3.8	<.1	0.2
2CK1	7.3	7.8			26.4									
2CK2	7.5	8.1			26.8									

PHYSICAL DATA (SURVEY)

PARTICLE SIZE ANALYSIS

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE1					1	1	2	13	12	29		65	6	1
BM					1	2	2	5	11	21		71	8	
AE2					1	4	8	11	8	32		50	18	2
2BT					2	4	6	8	5	25		38	37	12
2CK1	99	96	79	47	3	6	7	9	8	33		41	26	7
2CK2	99	95	77	47	3	4	6	9	7	29		45	26	9

PHYSICAL DATA

ENGINEERING

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AE1								
BM								
AE2								
2BT								
2CK1	10.0	15.0		13.0	1.9		24	04
2CK2	11.0	13.0		11.0	2.0		26	04

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2	EXTR PH (%)
LF					
AE1					
BM	0.1	1.4	0.1	0.5	0.0
AE2					
2BT					
2CK1					
2CK2					

Table 113 Pedon (Alberta 1978 No. 22) description of a Rego Gleysol in wet depressional segments of the BK1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: REGO GLEYSOL. SOIL MAP UNIT: NOTATION: BK1. SOIL PHASES: PEATY.

LOCATION: MILITARY GRID REF. 11 UMJ 7270 770; NTS MAP AREA 83C 6*.

CLIMATE: 1570 METERS ABOVE MEAN SEA LEVEL. STATION AT COLUMBIA ICEFLD HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 3 DEG(C) AT 20 CM IN SEPTEMBER, NO. 2 WAS 4 DEG(C) AT 100 CM IN SEPTEMBER.

VEGETATION: VPN=IC8095*VTN=011.

SOIL SITE: PARENT MATERIAL 1: FLUVIOLACUSTRINE, ORGANIC MATERIAL (UNDIFFERENTIATED); PARENT MATERIAL 2: UNSPECIFIED WEATHERING, UNDIFFERENTIATED AND FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), WEAKLY CALCAREOUS (1 TO 6% CACO3), FLUVIOLACUSTRINE; PARENT MATERIAL 3: UNSPECIFIED WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), MORAINAL (TILL), LIMESTONE AND QUARTZITE; LANDFORM CLASSIFICATION: MORAINAL, HUMMOCKY; SLOPE: 4% SIMPLE SLOPE OF CLASS 3 (2-5%), FACING WEST, SITE AT DEPRESSION POSITION, 200 M LONG; SOIL MOISTURE AND DRAINAGE: POORLY DRAINED, SLOWLY PERVIOUS, SEEPAGE PRESENT, 1 M TO WATERTABLE; SLIGHTLY STONY; NONROCKY; PRESENT LAND USE: SWAMP; HUMUS-FORM: HUMIC.

SPECIAL NOTES: SSN=RWB072*AFN=010-188*PCF=3GR(4-6)3CB(3-6)*MOTTLES IN 2CKG HORIZON OCCUR IN ROOT CHANNELS*LFH*MN*SLOPE IS SIMPLE ACPOSS DEPRESSION,COMPLEX OF CLASS 5 OVER TRACT*

OF: 17 TO 11 CM, RANGE 5 TO 7 CM; HORIZON MOIST; ORGANIC; ABUNDANT, FINE AND MEDIUM AND COARSE, RANDOM ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

OH: 11 TO 0 CM, RANGE 9 TO 12 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/1; ORGANIC; ABUNDANT, FINE AND MEDIUM AND COARSE, RANDOM ROOTS; SMOOTH, CLEAR HORIZON BOUNDARY.

2CKG: 0 TO 15 CM, RANGE 15 TO 16 CM; HORIZON MOIST; MATRIX MOIST 2.5Y 5/2, MATRIX MOIST 10YR 5/3; LOAM; FEW, FINE, PROMINENT, 2.5YR 4/6 MOTTLES; STRUCTUPELESS, MASSIVE STRUCTURE; SLIGHTLY STICKY, FRIABLE CONSISTENCE; PLENTIFUL, FINE, RANDOM ROOTS; MODERATELY POROUS, COMMON, FINE, RANDOM, DISCONTINUOUS, DENDRITIC, TUBULAR PORES; MODERATE EFFERVESCENCE; WEAKLY CALCAREOUS; 10% COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

3CKG1: 15 TO 39 CM, RANGE 6 TO 24 CM; HORIZON MOIST; MATRIX MOIST 2.5Y 6/2; LOAM; FEW AND COMMON, FINE AND MEDIUM, PROMINENT, 10YR 5/6 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; SLIGHTLY STICKY, FRIABLE CONSISTENCE; FEW, FINE, VERTICAL ROOTS; SLIGHTLY POROUS, FEW, FINE, VERTICAL, DISCONTINUOUS, SIMPLE, TUCULAR PORES; MODERATE EFFERVESCENCE; STRONGLY CALCAREOUS; 20% GRAVELLY AND COBBLY COARSE FRAGMENTS; SMOOTH, CLEAR HORIZON BOUNDARY.

3CKG2: 39 TO 85 CM, RANGE 40 TO 65 CM; HORIZON MOIST; MATRIX MOIST 2.5Y 5/4; LOAM; MANY, MEDIUM AND COARSE, DISTINCT, 5Y 6/2 MOTTLES; STRUCTUPELESS, MASSIVE STRUCTURE; SLIGHTLY STICKY, FRIABLE CONSISTENCE; VERY FEW, FINE, VERTICAL ROOTS; SLIGHTLY POROUS, FEW, FINE, VERTICAL, DISCONTINUOUS, SIMPLE, TUBULAR PORES; MODERATE EFFERVESCENCE; VERY STRONGLY CALCAREOUS; 20% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

3CKG3: 85 TO 95 CM; HORIZON MOIST; MATRIX MOIST 5Y 6/2; LOAM; COMMON, MEDIUM, PROMINENT, 2.5Y 5/6 MOTTLES; COARSE, PLATY STRUCTURE PSEUDO; SLIGHTLY STICKY, FRIABLE CONSISTENCE; MODERATE EFFERVESCENCE; VERY STRONGLY CALCAREOUS AND VERY STRONGLY CALCAREOUS; 20% GRAVELLY AND COBBLY COARSE FRAGMENTS.

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS												
	% PASSING									% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
OF														
OH														
2CKG	99			93	0	1	4	11	10	26		48	26	
3CKG1	99			89	3	6	9	18	12	48		41	11	
3CKG2	99			82	4	6	10	19	12	51		40	9	
3CKG3					6	4	6	7	5	28		46	26	

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
OF	5.1	46.10	
OH	6.3	34.50	
2CKG	7.1	1.00	2.5
3CKG1	7.4	0.10	23.0
3CKG2	7.6	3.60	31.5
3CKG3	7.6	0.20	37.5

PHYSICAL DATA

	MOISTURE STATUS (%)					ENGINEERING						
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
OF													
OH													
2CKG		23.6	12.5			14.0	28.0		12.0	1.9		60	10
3CKG1						9.0	14.0					40	19
3CKG2		12.5	3.6			7.0	11.0					40	18
3CKG3		15.6	9.7										

Vegetation

Vegetation of the BK1 Ecosite is distributed in a pattern governed by drainage conditions. The closely related lodgepole pine/buffaloberry/grouseberry (C18) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s dominate the well drained, mesic upland segments and reflect the extensive effects of fire in the Lower Subalpine. Lodgepole pine/buffaloberry/showy aster (C6) at low elevations and lodgepole pine/false azalea/grouseberry (C20) in western regions of the parks are important

accessory v.t.s. Lodgepole pine/juniper/bearberry (C3), including a variant with high spruce cover occurring in eastern Banff, lodgepole pine/green alder/feathermoss (C10), lodgepole pine/feathermoss (C11) and lodgepole pine/Labrador tea (C29) occur in minor amounts. Modification of the vegetation by recent fires has occurred in some areas. A stand representing vegetation of the pedon sampling site described above (Table 112) and illustrating the C18 v.t. of upland segments of the BK1 Ecosite is presented in Table 114 and Plate 88.

Table 114 Stand (JD6094) illustrating the lodgepole pine / buffaloberry / grouseberry (C18) v.t. of dry upland segments of the BK1 Ecosite.

TREE LAYER	
Picea glauca	.5
Pinus contorta	55
TALL SHRUB LAYER	
Picea glauca	.5
SHRUB LAYER	
Abies lasiocarpa	.5
Juniperus communis	.5
Lonicera involucrata	.5
Picea glauca	.5
Pinus contorta	.5
Potentilla fruticosa	.5
Rosa acicularis	01
Salix glauca	01
Shepherdia canadensis	30
HERB-DWARF SHRUB LAYER	
Achillea millefolium	.5
Arctostaphylos uva-ursi	05
Arnica cordifolia	.5
Aster ciliolatus	01
Aster conspicuus	02
Carex scirpoidea	.5
Cornus canadensis	02
Elymus innovatus	07
Epilobium angustifolium	.5
Fragaria virginiana	05
Hedysarum sulphurescens	.5
Linnaea borealis	20
Pyrola secunda	01
Pyrola virens	.5
Senecio indecorus	.5
Solidago multiradiata	.5
Vaccinium caespitosum	05
Vaccinium scoparium	15
BRYOID LAYER	
Brachythecium spp.	.5
Cladonia spp.	.5
Dicranum spp.	.5
Drepanocladus uncinatus	.5
Peltigera aphthosa	.5
Pleurozium schreberi	.5
Ptilium crista-castrensis	.5
Barbilophozia hatcheri	.5
Stereocaulon spp.	.5
EPIPHYTES	
Alectoria spp.	.5
Parmelia spp.	.5
Parmeliopsis spp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation of depressional segments, dominated by the spruce/Labrador tea/brown moss (O11), dwarf birch-shrubby cinquefoil-willow/brown moss (S1) and dwarf birch-shrubby cinquefoil needlerush (S3) v.t.s, reflects poor drainage. S1 is most abundant

Table 115 Stand (IC8095) illustrating the spruce/-Labrador tea/brown moss (011) v.t. of wet depressional segments of the BK1 Ecosite.

TREE LAYER	
Picea mariana	12
Pinus contorta	.5
TALL SHRUB LAYER	
Picea mariana	05
Pinus contorta	.5
SHRUB LAYER	
Betula pumila	05
Juniperus communis	.5
Ledum groenlandicum	25
Picea mariana	02
Pinus contorta	.5
Potentilla fruticosa	.5
Rosa acicularis	.5
Salix glauca	05
HERB-DWARF SHRUB LAYER	
Achillea millefolium	.5
Anemone parviflora	.5
Arctostaphylos rubra	01
Aster ciliolatus	.5
Carex capillaris	10
Cornus canadensis	01
Elymus innovatus	.5
Empetrum nigrum	01
Fragaria virginiana	.5
Juncus balticus	01
Linnaea borealis	04
Mitella nuda	.5
Oxycoccus microcarpus	.5
Petasites palmatus	01
Pyrola asarifolia	01
Rubus acaulis	01
Vaccinium vitis-idaea	06
Viola adunca	.5
Equisetum arvense	.5
Equisetum scirpoides	.5
Equisetum variegatum	01
BRYOID LAYER	
Aulacomnium palustre	05
Brachythecium spp.	.5
Bryum pseudotriquetrum	.5
Campylium chrysophyllum	.5
Ceratodon purpureus	.5
Cladonia mitis	.5
Cladonia pyxidata	.5
Dicranum fuscescens	05
Ditrichum flexicaule	.5
Drepanocladus spp.	05
Peltigera aphthosa	.5
Peltigera rufescens	.5
Pleurozium schreberi	20
Sphagnum varnstorfii	05
Tomenthypnum nitens	25
Tortella fragilis	.5
EPIPHYTES	
Parmelia exasperatula	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

but some depressions are dominated by O11 or S3. Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6), Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14) and water sedge-beaked sedge (H11) occur in minor amounts. A stand representing vegetation of the pedon sampling site described above (Table 113) and illustrating the *O11 v.t. of wet depressions of the* BK1 Ecosite is described in Table 115.

Discussion

The BK1 Ecosite encompasses a compound landscape pattern consisting of well drained upland segments similar to the Panorama Ridge 2 (PR2) Ecosite and poorly to very poorly drained depressional segments similar to the Consolation Valley 1 (CV1) Ecosite and occasionally, the Hector 1 (HC1) and Hector 4 (HC4) Ecosites. The proportion of wet depressions on BK1 tracts commonly ranges from 20 to 40%. Map presentation of BK1 tracts at scales larger than 1:50,000 is invalid because these segments would become mappable as separate Ecosites. The BK1 Ecosite is separated from BK4 by genetic material differences, and from BK6 by genetic material and vegetation differences as outlined in Table 111. The Patricia 5 (PT5) Ecosite is the Montane counterpart of BK1.

BK4 - BAKER CREEK 4 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, BK4, occurs on hummocky or ridged, moraine-like, glacial landforms consisting of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). Landform surface expression may be of depositional origin or controlled by underlying bedrock. Its complex topography forms a compound landscape comprised of about 70% dry (well drained, mesic) upland segments and 30% wet (poorly to very poorly drained, hygric to hydric) depressions between ridges and hummocks. Upland segments are characterized by a soil pattern in which Eluviated Eutric Brunisols are dominant; Orthic Eutric Brunisols and Brunisolic Gray Luvisols are subdominant. Luvisolic tendencies are common in the Brunisolic soils. Vegetation of upland segments is dominated by the lodgepole pine/buffaloberry/grouseberry (C18) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s. Wet depressional segments contain pedogenically related wet soils, best represented by the Rego Gleysol and Terric Mesisol Subgroups. Associated wet vegetation usually includes the spruce/Labrador tea/brown moss (O11), dwarf birch-shrubby cinquefoil-willow/brown moss (S1), and/or dwarf birch-shrubby cinquefoil/needlerush (S3) v.t.s, with S1 being most abundant.

Geomorphology

The BK4 Ecosite is typified by moraine-like glacial landforms consisting of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). A low lime phase occurs occasionally. Tracts of BK4 in the vicinity of Topaz 1 (TZ1) or Topaz 2 (TZ2) tracts occur on ice contact stratified material with low lime content and coarse textures (e.g. Athabasca River valley below the Chaba River confluence). Surficial veneers of altered, medium textured eolian material (Eolian material B) occur extensively on BK4 tracts located in western Banff and southwestern Jasper, sporadically elsewhere. Depressional segments are usually thinly mantled by peat derived primarily from sedges and brown mosses (e.g. *Tomenthypnum nitens* and *Aulacomnium palustre*). This fen peat, rarely exceeding 1.2 m in thickness, is mainly moderately decomposed but fibric and humic layers also occur. Occasionally, wood fragments may be found. Where this peat is >40 cm thick, the landform is classified as horizontal fen (C.S.S.C. 1978b), recognizing that in some localities, fen vegetation has been succeeded by open forest. The fen peat is underlain, within the control section, by till, occasionally by calcareous, coarse, stratified fluvial material (Fluvial material B) and altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) veneers. In some sites, volcanic ash is well preserved in eolian or fluviolacustrine veneers at or near the organic layer's lower boundary.

Topographically, the BK4 Ecosite displays a series of parallel ridges or irregularly distributed knolls separated by gently sloping depressions. Slopes commonly range from 5 to 30%, although a few BK4 tracts with slopes ranging to 45% occur. Depressional segments, usually with slopes <5%, may be level with sharp borders to upland segments or concave and bowl shaped with subtle margins. The ridged and hummocky surface expressions may reflect underlying bedrock surfaces or be of depositional origin. Kettle-holes, kames and eskers are outstanding depositional features that occur on some BK4 tracts. Small glaciofluvial terraces occur occasionally. Veneers of ice contact stratified material occur locally on some ridge and hummock crests but dominate on the few BK4X tracts mapped. Bedrock outcrops are not common except on BK4+R tracts.

Soils

Soils of the BK4 Ecosite are distributed in a pattern governed by drainage conditions. Soils of the well drained, upland segments are distributed in a pattern reflecting the thickness of the eluvial (Ae) horizon and degree of luvisolic development. Eluviated Eutric Brunisols are dominant, Orthic Eutric

Table 116 Pedon (Alberta 1979 No. 94) description of an Eluviated Eutric Brunisol of dry upland segments of the BK4 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: BK4.

LOCATION: MILITARY GRID REF. 11 UNN 8170 2460; NTS MAP AREA 82O 12W.

CLIMATE: 1700 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 6 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JD9085=VTN=C6=.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), UNDIFFERENTIATED, EOLIAN; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND STRATIFIED (MINERAL), EXTREMELY CALCAREOUS (>40% CACO3), GLACIOFLUVIAL AND MORAINAL (TILL); LANDFORM CLASSIFICATION: GLACIO FLUVIAL AND MORAINAL, RIDGED; SLOPE: 25% COMPLEX SLOPE OF CLASS 6 (16-30%), FACING NORTHEAST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,30 M LONG; SOIL MOISTURE AND DRAINAGE: SEMIARID, WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY.

SPECIAL NOTES: SSN=MT9153=APN=015-160=RLU=15=PCF=1GR,1CB(2-4)2GR,2CB(5)4GR,3CB(6)5GR,2CB(7)1GR,1CB(8)4GR,3CB,3ST(9) =LFH=MFGR=DATE=SEPT.7,1979=DEPENDENT UPON THE % OF CLAY SKINS IN THIN SECTION THISPEDON SHOULD PERHAPS BE CLASSIFIED AS BRUNISOLIC GRAY LUVISOL=

LF: 4 TO 0 CM, RANGE 1 TO 4 CM; MATRIX MOIST 10YR 2/1; WAVY, CLEAR HORIZON BOUNDARY.

AEJ: 0 TO 1 CM, RANGE 0 TO 2 CM; MATRIX MOIST 10YR 6/2; LOAM; WEAK, FINE, PLATY STRUCTURE; SOFT CONSISTENCE; FEW, COARSE ROOTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

BM: 1 TO 8 CM, RANGE 6 TO 9 CM; MATRIX MOIST 7.5YR 5/4; LOAM; WEAK, FINE, ANGULAR BLOCKY STRUCTURE; SOFT CONSISTENCE; FEW, COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AE: 8 TO 11 CM, RANGE 3 TO 5 CM; MATRIX MOIST 7.5YR 6/4; LOAM; WEAK, FINE, ANGULAR BLOCKY STRUCTURE; SOFT CONSISTENCE; FEW, COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

2BTJ: 11 TO 22 CM, RANGE 8 TO 12 CM; MATRIX MOIST 10YR 5/4; CLAY LOAM; STRONG, MEDIUM, ANGULAR BLOCKY STRUCTURE; SLIGHTLY HARD CONSISTENCE; FEW, FINE ROOTS; FEW, THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; WAVY, CLEAR HORIZON BOUNDARY.

2BCK: 22 TO 31 CM, RANGE 8 TO 10 CM; MATRIX MOIST 10YR 3/2.5; FINE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT CONSISTENCE; FEW, FINE ROOTS; MODERATE EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

2CK1: 31 TO 57 CM, RANGE 24 TO 30 CM; MATRIX MOIST 10YR 5/1.5; COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT CONSISTENCE; FEW, FINE AND MEDIUM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; IRREGULAR, CLEAR HORIZON BOUNDARY.

2CK2: 57 TO 72 CM, RANGE 10 TO 25 CM; MATRIX MOIST 10YR 5/1; GRAVELLY SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; HARD CONSISTENCE; STRONGLY CEMENTEDBY LIME, DISCONTINUOUS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; IRREGULAR, CLEAR HORIZON BOUNDARY.

2CK3: 72 TO 105 CM; MATRIX MOIST 10YR 5/2; GRAVELLY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT CONSISTENCE; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	5.4	42.40							
AEJ									
BM	5.8	1.70		13.9		14.5	2.8	0.1	0.5
AE	4.9	1.30		15.7		10.1	2.4	0.1	0.4
2BTJ	6.2	1.90		22.7		21.9	3.7	0.1	0.5
2BCK	7.3		55.1						
2CK1	7.3		90.8						
2CK2	7.6		85.8						
2CK3	7.7		88.5						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AEJ				
BM	0.1		-.1	
AE				
2BTJ				
2BCK				
2CK1				
2CK2				
2CK3				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AEJ						1	2	8	19	30		48	22	
BM						1	2	11	20	34		43	23	
AE							2	12	17	31		36	33	
2BTJ					8	9	7	18	15	57		33	10	
2BCK					13	15	12	12	8	60		34	6	
2CK1					10	14	13	17	9	63		33	4	
2CK2	99	96	72	58	8	10	11	12	10	51		42	7	
2CK3	99	83	68	60										

PHYSICAL DATA

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	ENGINEERING AASHO CLASS	UNIFIED CLASS
LF								
AEJ								
BM								
AE								
2BTJ								
2BCK								
2CK1							12	07
2CK2							24	07
2CK3								

Brunisols and Brunisolic Gray Luvisols subdominant. These soils have weak textural B horizons, some with sufficient pedogenic clay film development to be Bt horizons, occurring at or slightly below the glacial material surface. Iron, aluminum, and humus enriched Bm horizons developed in the altered, medium textured eolian (Eolian material B) veneers may overlie the textural B horizons. Orthic Gray Luvisols occur in minor amounts. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly expressed in the absence of altered, medium textured eolian material. In some localities surface erosion inhibits Ae development. Lithic soils are common only on BK4X tracts. Gleyed Eutric Brunisols, Gleyed Eluviated Eutric Brunisols, Gleyed Brunisolic Gray Luvisols and Gleyed Gray Luvisols often occur in narrow transitional belts surrounding wet depressions. A pedon illustrating Eluviated Eutric Brunisols of upland segments of the BK4 Ecosite is described in Table 116 and shown in Color Plate 5. The sampling site is shown in Plate 89.

A variety of pedogenically related soils occur on the poor to very poorly drained, depressional segments of the BK4 Ecosite. These are best represented by the Rego Gleysol and Terric Mesisol Subgroups. Mineral layers are usually strongly gleyed reflecting high water tables and long periods of saturation; conditions that inhibit pedogenic horizonation. Orthic Gleysols are important accessory soils in localities with shorter periods of saturation such as depressions with drainage outlets and raised margins of depressions. Favorable moisture, nutrient, and vegetation conditions have resulted in the accumulation of varying thicknesses of fen peat on the depressional soils. Terric Mesisols occur where the peat is >40cm thick. Other Organic soils with subdominant humic or fibric layers, gleyed Podzols, gleyed Regosols and Humic Gleysols occur occasionally. The pedon described in Table 113 for wet depressions of the BK1 Ecosite illustrates Rego Gleysols occurring on the BK4 Ecosite.

Vegetation

Vegetation of the BK4 Ecosite is distributed in a pattern governed by drainage conditions. The closely related lodgepole pine/buffaloberry/grouseberry (C18) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s dominate the well drained, mesic upland segments and reflect the extensive effects of fire in the Lower Subalpine. Lodgepole pine/juniper/bearberry (C3), lodgepole pine/buffaloberry/showy aster (C6), lodgepole pine/false azalea/grouseberry (C20) and lodgepole pine/Labrador tea (C29) are commonly occurring accessory v.t.s. The C3 v.t. is common on subxeric to mesic, well to rapidly drained, exposed sites such as prominent ridge and hummock crests. On some tracts near Banff's eastern boundary, a C3 variant with significant amounts of spruce is quite common. The C6 is closely related to the dominant v.t.s and occurs with them at low elevations. The C20 v.t. occurs primarily in the Main Ranges; C29 is most abundant in eastern Jasper. Lodgepole pine/feathermoss (C11) occurs in minor amounts. Modification by recent fires has occurred in some localities. A stand illustrating the C19 v.t. of upland segments of the BK4 Ecosite is described in Table 117. This stand is located about 1 km up valley from the pedon sample site described in Table 116.

Table 117 Stand (JE8021) illustrating the lodgepole pine/buffaloberry/twinflower (C19) v.t. of dry upland segments of the BK4 Ecosite.

TREE LAYER	
Picea engelmannii	03
Pinus contorta	22
TALL SHRUB LAYER	
Picea engelmannii	03
Pinus contorta	03
SHRUB LAYER	
Picea engelmannii	01
Pinus contorta	01
Salix bebbiana	.5
Salix glauca	.5
Shepherdia canadensis	28
HERB-DWARF SHRUB LAYER	
Arctostaphylos uva-ursi	02
Arnica cordifolia	02
Aster conspicuus	.5
Elymus innovatus	1
Epilobium angustifolium	.5
Fragaria virginiana	.5
Hedysarum alpinum	.5
Hedysarum sulphurescens	.5
Linnaea borealis	05
Pyrola secunda	.5
Erigeron spp.	.5
BRYOID LAYER	
Brachythecium sp.	.5
Cetraria cucullata	.5
Cetraria nivalis	.5
Cladonia cenotea	.5
Cladonia ecmocyna	01
Cladonia gracilis	.5
Cladonia pyxidata	.5
Cladonia spp.	.5
Drepanocladus uncinatus	10
Hylocomium splendens	05
Hypnum revolutum	.5
Lecidea sp.	.5
Orthotrichum jamesianum	.5
Peltigera aphthosa	02
Peltigera canina	02
Ptilium crista-castrensis	01
Stereocaulon alpinum	.5
Tortula ruralis	.5
Xanthoria elegans	.5
EPIPHYTES	
Cetraria pinastri	.5
Hypogymnia austerodes	.5
Parmelia sulcata	.5
Parmeliopsis ambigua	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Vegetation of depressional segments, dominated by the spruce/Labrador tea/brown moss (O11), dwarf birch-shrubby cinquefoil-willow/brown moss (S1) and dwarf birch-shrubby cinquefoil/needlerush (S3) v.t.s, reflects poor drainage. The S1 v.t. is most abundant but some depressions are dominated by O11 or S3. Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6), Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14) and water sedge-beaked sedge (H11) occur in minor amounts. A stand illustrating the S3 v.t. of wet depressional segments of the BK4 Ecosite is described in Table 118. Plate 90 shows a shrub dominated wet depression common on the Baker Creek (BK) Ecosites.

Table 118 Stand (PA7016) illustrating the dwarf birch-shrubby cinquefoil/ needlerush (S3) v.t. of wet depressional segments of the BK4 Ecosite.

SHRUB LAYER	
Betula pumila	15
Potentilla fruticosa	05
Salix candida	01
HERB-DWARF SHRUB LAYER	
Carex aquatilis	10
Pedicularis groenlandica	01
Scirpus caespitosus	50
BRYOID LAYER	
Aulacomnium palustre	.5
Campylium stellatum	40
Drepanocladus revolvens	40
Tomenthypnum nitens	01

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

The BK4 Ecosite encompasses a compound landscape pattern consisting of well drained upland segments similar to the Panorama Ridge 6 (PR6) Ecosite and poorly to very poorly drained depressional segments similar to the Consolation Valley 1 (CV1) Ecosite, occasionally the Hector 1 (HC1) and Hector 4 (HC4) Ecosites. The proportion of wet depressions on BK4 tracts commonly ranges from 20 to 40%. Map presentation of BK4 tracts at scales larger than 1:50,000 is invalid because these segments would become mappable as separate Ecosites. BK4 is separated from BK1 by genetic material differences, from BK6 by vegetation differences as outlined in Table 111. In areas where the Patricia 5 (PT5) Ecosite occurs on calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B), it is the Montane counterpart of BK4.

BK6 - BAKER CREEK 6 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, BK6, occurs on hummocky or ridged glacial landforms consisting of calcareous, medium textured till (Till C) and calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). Landform surface expression may be of depositional origin or controlled by underlying bedrock. Its complex topography forms a compound landscape comprised of about 70% dry (well drained, mesic) upland segments and 30% wet (poorly to very poorly drained, hygric to hydric) depressions between ridges and hummocks. Upland segments are characterized by a soil pattern in which Eluviated Eutric Brunisols are dominant, Orthic Eutric Brunisols subdominant. Vegetation of upland segments is dominated by the Engelmann spruce-subalpine fir/feathermoss (C13) v.t. Wet depressional segments contain pedogenically related wet soils, best represented by the Orthic Gleysol, Rego Gleysol and Terric Mesisol Subgroups. Vegetation of depressions is dominated by the spruce/Labrador tea/brown moss (O11), dwarf birch-shrubby cinquefoil-willow/brown moss (S1) and dwarf birch-shrubby cinquefoil/needlerush (S3) v.t.s.

The BK6 Ecosite occurs more often on narrow valley bottom and headwall areas than does BK1 and BK4. Because of this slightly different physiographic position, BK6 exhibits a slightly different drainage pattern in which many depressions have drainage outlets whereas the BK1 and BK4 depressions are predominantly closed basins. This difference is reflected in the kind of soil that occurs in the wet depressions.

Geomorphology

The BK6 Ecosite is typified by glacial landforms consisting of calcareous, medium textured till (Till C) and calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). A low lime phase occurs occasionally. Surficial veneers of altered, medium textured eolian material (Eolian material B) occur extensively on BK6 tracts located in western Banff and southwestern Jasper and sporadically elsewhere. Depressional segments are usually thinly mantled by peat derived primarily from sedges and brown mosses (e.g. *Tomenthypnum nitens* and *Aulacomnium palustre*). This fen peat, rarely exceeding 1.2 m in thickness, is mainly moderately decomposed but fibric and humic layers also occur. Occasionally, wood fragments may be found. Where this peat is >40 cm thick, the landform is classified as horizontal fen (C.S.S.C. 1978b) recognizing that in some localities fen vegetation has been succeeded by open forest. The fen peat is underlain, within the control

section, by till, occasionally by calcareous, coarse, stratified fluvial (Fluvial material B) veneers, infrequently by altered, fine, stratified fluviolacustrine (Fluviolacustrine material A) veneers. The BK6 Ecosite has more open ended depressional basins than BK1 and BK4, consequently, fluvial veneers tend to be more abundant on BK6. In some sites, volcanic ash material is well preserved in eolian or fluviolacustrine veneers at or near the organic layer's lower boundary.

Topographically, the BK6 Ecosite displays a series of subparallel ridges or irregularly distributed knolls separated by gently sloping depressions. Slopes commonly range from 5 to 45%. Depressional segments, usually with slopes <5%, may be level with sharp borders to upland segments or concave and bowl shaped with subtle margins. The ridged and hummocky surface expressions may reflect underlying bedrock surfaces or be of depositional origin. Tracts of BK6 occasionally include failed till slopes. Small glaciofluvial terraces occur occasionally. Veneers of till or ice contact stratified material occur locally on some ridge and hummock crests and dominate on the few BK6X tracts mapped. Bedrock outcrops are not common except on BK6+R tracts.

Soils

Soils of the BK6 Ecosite are distributed in a pattern governed by drainage conditions. Soils of the well drained upland segments are distributed in a pattern reflecting the degree of eluvial (Ae) horizon development. Eluviated Eutric Brunisols are dominant, Orthic Eutric Brunisols subdominant. These soils have B horizons that range from the weak textural horizons frequently associated with weathering of calcareous glacial material to the comparatively advanced Bm and Bf horizons associated with altered, medium textured eolian material (Eolian material B). Orthic and Brunisolic Gray Luvisols and Orthic Humo-Ferric Podzols occur in minor amounts. Soils with luvisolic tendencies are especially evident on the drier slopes of eastern Banff and Jasper. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly expressed in the absence of altered, medium textured eolian material. In some localities surface erosion inhibits Ae development. Lithic soils are common only on BK4X tracts. Gleyed Eutric Brunisols and Gleyed Eluviated Eutric Brunisols often occur in narrow transitional belts surrounding wet depressions. The pedons described in Tables 137 and 138 for the Bryant 2 (BY2) and Bryant 4 (BY4) Ecosites illustrate Orthic Eutric Brunisols of upland segments of the BK6 Ecosite.

A variety of pedogenically related soils occurs on the poorly to very poorly drained, depressional segments of the BK6 Ecosite. These are best represented by the Orthic Gleysol, Rego Gleysol and Terric Mesisol Subgroups. Mineral layers are usually strongly gleyed reflecting high water tables and long periods of saturation; conditions that inhibit pedogenic horizonation. Recent and continuing fluvial activity in some localities inhibits pedogenic horizonation and organic material accumulation. Orthic Gleysols occur in localities with shorter periods of saturation such as depressions with drainage outlets and raised margins of depressions. Favorable moisture, nutrient and vegetation conditions have resulted in the accumulation of varying thicknesses of fen peat on most depressional soils. Terric Mesisols occur where the peat is >40 cm thick. Other Organic soils with subdominant humic or fibric layers, gleyed Podzols, gleyed Regosols and Humic Gleysols occur occasionally. The pedon described in Table 113 for wet depressions of the BK1 Ecosite illustrates Rego Gleysols occurring on the BK6 Ecosite.

Vegetation

Vegetation of the BK6 Ecosite is distributed in a pattern governed by drainage conditions. The Engelmann spruce-subalpine fir/feathermoss (C13) v.t. dominates the well drained upland segments. Engelmann spruce-subalpine fir/false azalea (C14), Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) are important accessory v.t.s. The C14 v.t. is common on relatively steep slopes in the Main Ranges, and C30 and C31 are more abundant in eastern Banff and Jasper, with C31 occurring mainly on southerly aspects. Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) occurs occasionally near the Continental Divide and in northern Jasper. Fire affected vegetation, in which spruce rather than pine is regenerating, occurs in some areas, e.g. upper Bryant Creek valley in Banff.

Vegetation of depressional segments, dominated by the spruce/Labrador tea/brown moss (O11), dwarf birch-shrubby cinquefoil-willow/brown moss (S1) and dwarf birch-shrubby cinquefoil/needlerush (S3) v.t.s. reflects poor drainage. Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6), Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14), willow/cinquefoil (S8) and water sedge-beaked sedge (H11) occur in minor amounts. A stand illustrating the S1 v.t. of wet depressional segments of the BK6 Ecosite is described in Table 119.

Discussion

The BK6 Ecosite encompasses a compound landscape pattern consisting of well drained upland segments similar to the Bryant 2 (BY2) or Bryant 4 (BY4) Ecosites and poorly to very poorly drained depressional seg-

Table 119 Stand (PA8109) illustrating the dwarf birch-shrubby cinquefoil-willow/brown moss (S1) v.t. of wet depressional segments of the BK6 Ecosite.

SHRUB LAYER	
Betula glandulosa	.5
Salix farrae	.5
Salix glauca	60
HERB-DWARF SHRUB LAYER	
Achillea millefolium	03
Agoseris glauca	.5
Arabis drummondii	.5
Aster ciliolatus	01
Carex limnophila	05
Cerastium arvense	.5
Delphinium glaucum	05
Deschampsia caespitosa	35
Elymus innovatus	05
Epilobium angustifolium	01
Erigeron peregrinus	15
Festuca saximontana	.5
Fragaria virginiana	.5
Gentiana amarella	.5
Penstemon procerus	01
Potentilla diversifolia	.5
Solidago multiradiata	.5
Trisetum spicatum	.5
Valeriana sitchensis	05
BRYOID LAYER	
Brachythecium groenlandicum	.5
Bryum spp.	.5
Cladonia pyxidata	.5
Peltigera rufescens	.5
Tortula norvegica	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

ments similar to the Consolation Valley 1 (CV1), Hector 1 (HC1) or Hector 4 (HC4) Ecosites. The proportion of wet depressions on BK6 commonly ranges from 20 to 40%. Map presentation of BK6 tracts at scales larger than 1:50,000 is invalid because these wet and dry segments would become mappable as separate Ecosites. The BK6 Ecosite is separated from BK1 and BK4 by vegetation differences as outlined in Table 111. In terms of physiographic position, landform surface expression and vegetation cover, BK6 resembles the Cavell 1 (CA1) Ecosite. However, CA1 occurs on morainal landforms consisting of noncalcareous, medium textured till (Till B) and is dominated by acidic soils (Dystric Brunisols). The Peyto Lake 5 (PL5) Ecosite is the Upper Subalpine counterpart of BK6.

BP - BOULDER PASS ECOSECTION

The Boulder Pass (BP) Ecosection encompasses stabilized, hummocky landslide (colluvial) deposits that are variably textured and derived from either calcareous or noncalcareous bedrock. It is dominated by Brunisolic and Regosolic soils associated with mixed coniferous open forest, Engelmann spruce-subalpine fir open and closed forests, and subalpine larch-subalpine fir forest. The BP Ecosection occurs on most physiographic positions in the Upper Subalpine portion of the Subalpine Ecoregion in both parks.

Two Boulder Pass Ecosites are differentiated primarily on vegetational differences as outlined in Table 120. Fig. 32 shows physiographic positions of BP1 and BP2 Ecosites in relation to adjacent Ecosites.

BP1 - BOULDER PASS 1 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, BP1, encompasses stabilized, hummocky landslide (colluvial) deposits that are variably textured and derived from either calcareous or noncalcareous bedrock. The BP1 Ecosite is dominated by rapidly to well drained Orthic Eutric Brunisols, Orthic Dystric Brunisols, and Orthic Regosols associated with the Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) v.t.

Geomorphology

The BP1 Ecosite encompasses stabilized, hummocky landslide (colluvial) deposits. Extinct rock glaciers are occasionally included. These postglacial deposits usually overlie morainal or bedrock surfaces. They range from medium acid to extremely calcareous in reaction and, texturally, from silt loam to loamy sand. The deposits have a high proportion of variably sized angular and subangular coarse fragments. Tracts of BP1 often have a high proportion of the surface occupied by stones and boulders. Surface expression is hummocky with a wide range of slopes, most often

Table 120 General features of the Boulder Pass (BP) Ecosites.

Ecosite	Landform	Soils	Vegetation
BP1	Landslide material; hummocky	Brunisolic, Regosolic	mixed coniferous open forest
BP2	Landslide material; hummocky	Brunisolic	Engelmann spruce-subalpine fir open and closed forests, subalpine larch-subalpine fir forest

Figure 32 Landscape schematic showing the relationship of the Boulder Pass (BP) Ecosite to other Ecosites.

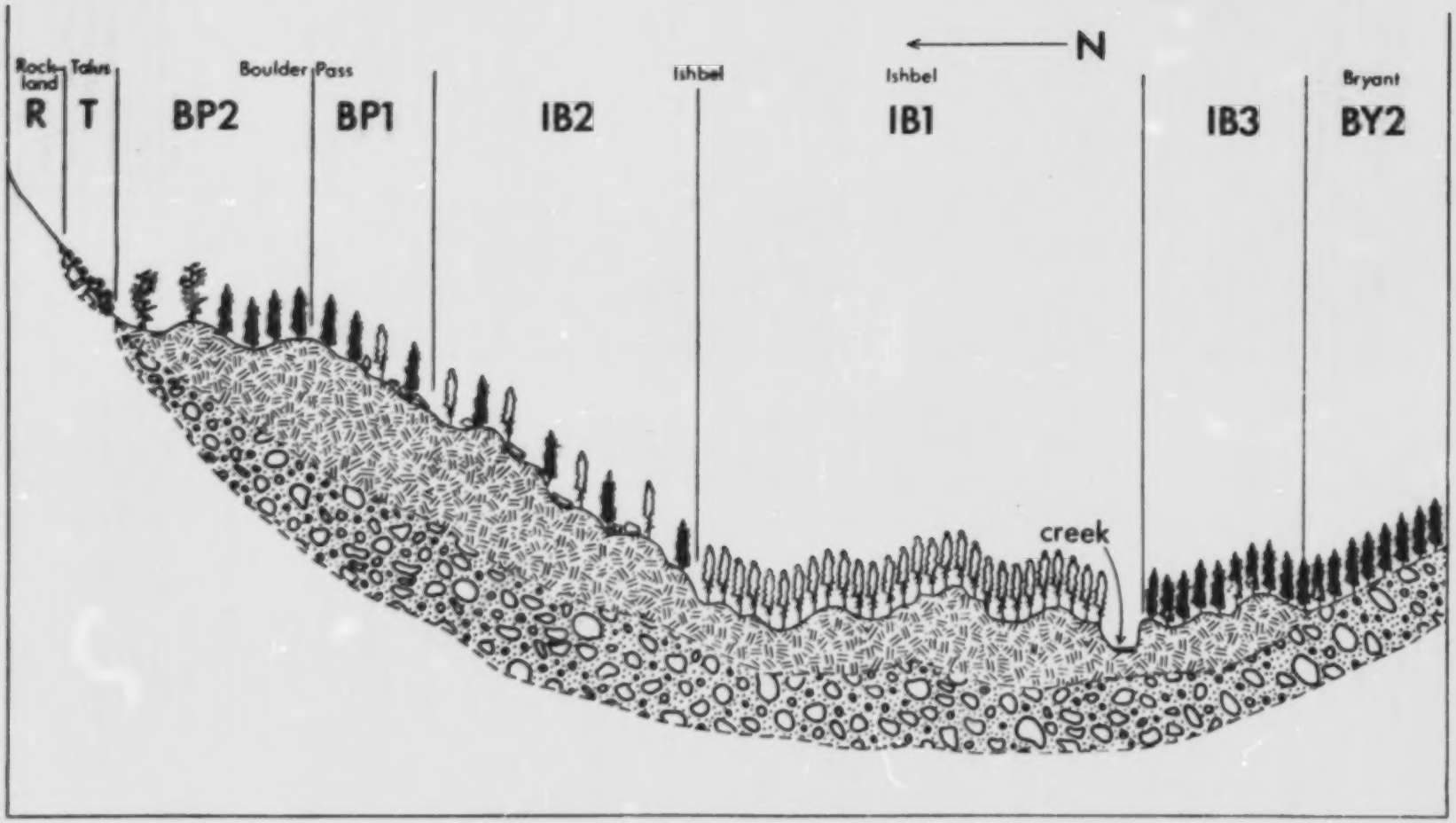


Table 121 Pedon (Alberta 1979 No. 20) description of an Orthic Eutric Brunisol of the BP1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: BP1.

LOCATION: MILITARY GRID REF. 11 UMJ 7780 188; NTS MAP AREA 83C 6.

CLIMATE: 2230 METERS ABOVE MEAN SEA LEVEL. STATION AT COLUMBIA ICEFLD

VEGETATION: VMH:JE91644VT6HD09.

SOIL SITE: PARENT MATERIAL 1: COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), COLLUVIAL, SILTSTONE AND MUDSTONE AND LIMESTONE; LANDFORM CLASSIFICATION: COLLUVIAL, HUMMOCKY AND INCLINED; SLOPE: 37% COMPLEX SLOPE OF CLASS 7 (31-48%), FACING WEST; SITE AT UPPER SLOPE POSITION; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY.

SPECIAL NOTES: SSH=CA9138+APH=618-086+PCF+2AG:234AB:3-4:1AB.2AC:5-6:1+LOW=CHI+DATE=SEPT.7,1979+

L: 1 TO 0 CM, RANGE 0 TO 2 CM; HORIZON MOIST; MATRIX MOIST 5YR 2.5/2.

AH: 0 TO 4 CM, RANGE 0 TO 8 CM; HORIZON MOIST; MATRIX MOIST 5YR 3/3; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE, VERTICAL ROOTS; MODERATELY POROUS; 10% ANGULAR GRAVELLY COARSE FRAGMENTS; BROKEN, CLEAR HORIZON BOUNDARY.

BM: 4 TO 17 CM, RANGE 7 TO 15 CM; HORIZON MOIST; MATRIX MOIST 5YR 3/4; GRAVELLY SANDY LOAM; VERY WEAK, VERY FINE TO FINE, GRANULAR STRUCTURE; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE, VERTICAL ROOTS; MODERATELY POROUS; 30% ANGULAR GRAVELLY COARSE FRAGMENTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

CK1: 17 TO 27 CM, RANGE 7 TO 12 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6; GRAVELLY SILT LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, FINE, VERTICAL ROOTS; MODERATELY POROUS; WEAK EFFERVESCENCE; EXTREMELY CALCAREOUS; 30% ANGULAR GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK2: 27 TO 55 CM, RANGE 16 TO 28 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6; LOAMY FINE SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, MICRO AND FINE, VERTICAL ROOTS; MODERATELY POROUS; WEAK EFFERVESCENCE; EXTREMELY CALCAREOUS; 20% ANGULAR GRAVELLY AND ANGULAR COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK3: 55 TO 62 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 6/6; LOAMY FINE SAND; STRUCTURELESS, SINGLE GRAIN STPUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, MICRO AND FINE, VERTICAL ROOTS; MODERATELY POROUS; WEAK EFFERVESCENCE; EXTREMELY CALCAREOUS; 20% ANGULAR GRAVELLY AND ANGULAR COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
L			
AH	6.7	6.58	9.0
BM	7.2	1.19	82.1
CK1	7.4		86.4
CK2	7.2		68.8
CK3	7.5		96.8

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2
L				
AH				
BM	0.1		-.1	
CK1				
CK2				
CK3				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 75-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
L														
AH								8	11	19		73	8	
BM					5	6	40	9	3	61		32	7	
CK1	99	62	52	51		1	2	17	22	42		56	2	
CK2										67		31	2	
CK3	99	70	60	58	10	4	5	21	27	67		23	10	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
L													
AH	92.1		26.2										
BM	45.4		9.8									24	07
CK1													
CK2												24	07
CK3	20.4		1.4										

between 15 and 70%. Tracts of BP1 occurring on valley walls display hummocky depositional surfaces superimposed upon inclined slopes that reflect the underlying bedrock or morainal surfaces. Surrounding tracts often include failed till slopes. Landslide scars often occur above and adjacent to tracts of BP1.

Soils

The BP1 Ecosite is dominated by rapidly to well drained Orthic Eutric Brunisols, Orthic Dystric Brunisols, and Orthic Regosols. These soils develop on landslide deposits that reflect the nature of the bedrock from which they have been derived. Orthic Eutric Brunisols develop on the more abundant calcareous slides and Eluviated Dystric Brunisols develop on the noncalcareous materials. Orthic Regosols occur more often on the calcareous bedrock-derived slides. Soils are absent on portions of tracts that have large amounts of stones and boulders on the surface (tracts mapped as BP1+CL). The soils on BP1 are often fragmental at depth. Small areas of Eluviated Eutric Brunisols and Eluviated Dystric Brunisols occur where discontinuous surficial veneers of altered, medium textured eolian material (Eolian material B) are present and are usually associated with patches of closed forest. Also, small areas of Orthic Melanic Brunisols and Orthic Sombric Brunisols occur on steep slopes that are subject to soil creep. A pedon described in Table 121 and shown in Color Plate 6 illustrates an Orthic Eutric Brunisol on BP1.

Vegetation

The BP1 Ecosite is dominated by the subxeric Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) v.t. This kind of vegetation is common on BP1 and appears to be related to the high amount of stones and boulders and the lack of fine earth material, a combination which makes tree establishment and growth difficult. Mountain avens-snow willow-moss campion (H1) and Engelmann spruce-subalpine fir/mountain avens (O1^{0}) are accessory v.t.s that occur on exposed slopes near the Upper Subalpine-Alpine boundary. Sparsely vegetated, very rubbly patches occur with O4 on tracts mapped as BP1+CL. Patches of the Engelmann spruce-subalpine fir/grouseberry (C15), subalpine larch-subalpine fir/grouseberry-everlasting (C23), and Engelmann spruce-subalpine fir/heather (O10) v.t.s usually indicate where more fine earth occurs and soils are better developed. A stand illustrating the O4 v.t. is described in Table 122 and shown in Plate 91 and represents the vegetation at the pedon sample site described above in Table 121. This plot contains more heather cover than is usual for the O4 v.t.

Table 122 Stand (JE9164) illustrating the Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (04) v.t. of the BP1 Ecosite.

TREE LAYER	
Abies lasiocarpa	01
Picea engelmannii	04
Pinus albicaulis	01
Pinus contorta	02
TALL SHRUB LAYER	
Abies lasiocarpa	03
Picea engelmannii	02
Pinus albicaulis	01
Pinus contorta	03
SHRUB LAYER	
Abies lasiocarpa	05
Juniperus communis	.5
Picea engelmannii	01
Pinus albicaulis	.5
Pinus contorta	01
Salix vestita	04
Shepherdia canadensis	.5
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	.5
Anemone parviflora	.5
Antennaria nitida	.5
Aquilegia flavescens	.5
Arctostaphylos uva-ursi	02
Arenaria rubella	.5
Aster alpinus	.5
Carex rupestris	01
Cassiope tetragona	08
Dryas octopetala	10
Elymus innovatus	.5
Gentiana amarella	.5
Phyllodoce glanduliflora	06
Picea engelmannii	.5
Poa alpina	.5
Silene acaulis	.5
Solidago multiradiata	.5
Trisetum spicatum	.5
Zygadenus elegans	.5
Selaginella densa	.5
BRYOID LAYER	
Barbilophozia hatcheri	.5
Brachythecium groenlandicum	.5
Candellariella aurella	.5
Cetraria cucullata	.5
Cetraria ericetorum	.5
Cetraria nivalis	.5
Cladonia pyxidata	01
Coelocaulon aculeatum	.5
Dermatocarpon cinereum	.5
Grimmia apocarpa	.5
Hypnum recurvatum	.5
Lecidea glomerulosa	.5
Lecidea spp.	.5
Lepraria neglecta	.5
Peltigera rufescens	.5
Peltigera spuria	.5
Psora decipiens	.5
Psora rubiformis	.5
Rinodina turfacea	.5
Solorina spongiosa	.5
Tortella fragilis	.5
Tortula ruralis	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

Vegetation differences separate BP1 from BP2 as outlined in Table 120. Portions of BP1 most resemble the Miscellaneous Landscape

CL (Colluvial Landslide). The latter is differentiated by the absence of soil and by less than 20% vegetation cover. The BP1 Ecosite is the Upper Subalpine counterpart of the Ishbell 2 (IB2) Ecosite.

BP2 - BOULDER PASS 2 ECOSITE

Ecosite Concept

The Boulder Pass 2 (BP2) Ecosite encompasses stabilized, hummocky landslide (colluvial) deposits that are variably textured and derived from either calcareous or noncalcareous bedrock. The BP2 is dominated by well to moderately well drained Orthic and Eluviated Eutric Brunisols associated with the Engelmann spruce-subalpine fir/grouseberry (C15), subalpine larch-subalpine fir/grouseberry-everlasting (C23), and Engelmann spruce-subalpine fir/heather (O10) v.t.s.

Geomorphology

The BP2 Ecosite encompasses stabilized, hummocky landslide (colluvial) deposits. Extinct rock glaciers are occasionally included. These postglacial deposits usually overlie morainal or bedrock surfaces. They range from medium acid to extremely calcareous in reaction and, texturally, from silt loam to loamy sand. The deposits have a high proportion of variably sized angular and subangular fragments. Tracts of BP2 have a low proportion of the surface occupied by stones and boulders compared to BP1. Surficial veneers of altered, medium textured eolian material (Eolian material B) occur extensively in western Banff and southwestern Jasper, sporadically elsewhere. Surface expression is irregular with a wide range of slopes, most often between 15 and 70%. The BP2 tracts occurring on valley walls display hummocky depositional surfaces superimposed upon inclined slopes that reflect the underlying bedrock or morainal surfaces. Surrounding tracts often include failed till slopes. Landslide scars often occur above and adjacent to tracts of BP2.

Soils

The BP2 Ecosite is dominated by well to moderately well drained Orthic and Eluviated Eutric Brunisols. These soils develop on calcareous landslide deposits that reflect the nature of the bedrock from which they have been derived. Orthic and Eluviated Dystric Brunisols occur in minor amounts on less frequently occurring noncalcareous landslide deposits. Soils associated with BP2 have better developed horizons than do BP1 soils. This is attributed to generally older, more weathered surfaces and the concomitant extensiveness of altered, medium textured eolian (Eolian material B) veneers in some areas. Podzolic soils occur in small amounts where Eolian material B is present. A pedon described in Table 123 and shown in Color Plate 7 illustrates an Eluviated Eutric Brunisol on BP2. This pedon was sampled at Boulder Pass below the southwest end of Ptarmigan Lake in Banff.

Table 123 Pedon (Alberta 1978 No. 36) description of an Eluviated Eutric Brunisol of the BP2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: BP2.

LOCATION: MILITARY GRID REF. 11 UBH 6310 320; NTS MAP AREA 82N 8E.

CLIMATE: 2300 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 3 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JE8151*VTN=C23*.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN, ASH; PARENT MATERIAL 2: FRAGMENTAL (STONES,COBBLES AND GRAVEL) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), COLLUVIAL; LANDFORM CLASSIFICATION: COLLUVIAL, HUMMOCKY; SLOPE: 26% COMPLEX SLOPE OF CLASS 6 (16-30%), FACING SOUTH, SITE AT UPPER SLOPE POSITION, SEVERELY MOUNDED MICROTOPOGRAPHY,60 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; EXCEEDINGLY STONY; HUMMOCKY.

SPECIAL NOTES: SSM=YA8142*APM=A24783-102*RLU=15*PCF=3AGR,3ACB,4ST(4)3ABM,4ACB,5ST(5)*LFH=CH*

LF: 3 TO 0 CM, RANGE 1 TO 4 CM; MATRIX MOIST 10YR 2/1; ABUNDANT, FINE AND MEDIUM ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 4 CM, RANGE 4 TO 10 CM; MATRIX MOIST 10YR 6/2; SILT LOAM; WEAK, MEDIUM, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; COMMON, FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

BM: 4 TO 13 CM, RANGE 5 TO 12 CM; MATRIX MOIST 7.5YR 4/6; SILT LOAM; VERY WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; FEW, MEDIUM ROOTS; COMMON, FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

2BM: 13 TO 19 CM, RANGE 8 TO 10 CM; MATRIX MOIST 7.5YR 5/6; SILT LOAM; WEAK TO MODERATE, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, MEDIUM ROOTS; COMMON, FINE PORES; 60% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2CK: 19 TO 85 CM; MATRIX MOIST 10YR 3/3; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; VERY FEW, MEDIUM ROOTS; MODERATE EFFERVESCENCE; MODERATELY CALCAREOUS; 60% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.5	34.60							
AE	4.7	3.80		23.9		5.4	0.8	0.1	0.3
BM	5.7	3.10		29.1		8.4	0.7	0.1	0.2
2BM	6.2	0.80		16.7		10.1	0.9	0.1	0.1
2CK	6.7		7.6						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	0.2		0.2	
2BM	0.1		-.1	
2CK				

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	PARTICLE SIZE ANALYSIS C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 78- CU SILT	58- CU SILT	CU CLAY	0.2U CLAY
LF														
AE										16		68	16	
BM										16		77	7	
2BM										13		66	21	
2CK		99	80	67	63					31		59	10	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE		42.4	11.1										
BM													
2BM													
2CK		25.4	6.7			24.0	29.0					48	87

Vegetation

The BP2 Ecosite is dominated by the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/heather (O10), and subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t.s. The C23 v.t. is the least extensive but dominates several BP2 tracts in southern Banff south of Hector Lake, Pipestone Pass, and the Panther River. Small amounts of the Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t. mainly occur on noncalcareous slides. Patches of open forest v.t.s and nonvegetated areas (CL) occur on portions of the landscape that have a high proportion of the surface occupied by stones and boulders. A vegetation plot description of the C23 v.t. is illustrated in Table 124 and shown in Plate 92 and represents the vegetation of the sampled pedon described in Table 123.

Table 124 Stand (JE8151) illustrating the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. of the BP2 Ecosite

TREE LAYER	
Abies lasiocarpa	09
Larix lyallii	08
Picea engelmannii	03
TALL SHRUB LAYER	
Abies lasiocarpa	12
Larix lyallii	02
Picea engelmannii	01
SHRUB LAYER	
Abies lasiocarpa	01
Larix lyallii	01
Picea engelmannii	.5
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	.5
Achillea millefolium	.5
Antennaria lanata	.5
Arnica cordifolia	.5
Cassiope mertensiana	15
Deschampsia atropurpurea	.5
Fragaria virginiana	.5
Hieracium gracile	.5
Juniperus communis	.5
Luzula wahlenbergii	.5
Phyllodoce glanduliflora	10
Polystichum lonchitis	.5
Vaccinium scoparium	07
BRYOID LAYER	
Barbilophozia hatcheri	.5
Barbilophozia lycopodioides	.5
Caloplaca holocarpa	.5
Candellariella xanthostigma	.5
Ceratodon purpureus	01
Cetraria ericetorum	.5
Cladonia coccifera	.5
Cladonia coniocraea	.5
Cladonia deformis	.5
Cladonia ecmocyna	.5
Cladonia pyxidata	.5
Diploschistes scruposus	.5
Grimmia apocarpa	.5
Hylocomium splendens	01
Hypnum revolutum	01
Lecanora rupicola	.5
Lecanora thamnoplaca	.5
Lecanora spp.	.5
Lecidea tessellata	.5
Lepraria incana	.5
Lophozia spp.	.5
Ochrolechia geminipara	.5
Orthotrichum laevigatum	01
Paraleucobryum enerve	.5
Peltigera aphthosa	01
Peltigera canina	.5
Peltigera polydactyla	.5
Physcia nigricans	.5
Physconia muscigena	.5
Pohlia nutans	01
Psoroma hypnorum	.5
Rhizocarpon disporum	.5
Rhizocarpon geographicum	.5
Xanthoria elegans	.5
EPIPHYTES	
Hypogymnia austerodes	.5
Hypogymnia bitteri	.5
Lecanora anseris	.5
Lecidea tessellata	.5
Letharia vulpina	.5
Parmelia exasperatula	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5
Alectoria spp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The BP2 Ecosite is separated from the BP1 Ecosite primarily on vegetational differences as outlined in Table 120. Copper 1 (CP1) Ecosite, when it occurs on failed slopes, resembles BP2. However, CP1 occurs on landforms consisting of noncalcareous, medium textured residuum (Residuum A) and is dominated by lithic phase Dystric Brunisols containing shaly or slaty coarse fragments that conform in orientation to the bedding planes in the underlying parent rock. The BP2 Ecosite is the Upper Subalpine counterpart of the Ishbell 3 (IB3) Ecosite.

BS - BOW SUMMIT ECOSECTION

The Bow Summit (BS) Ecosection encompasses steep, usually linear, colluvial landforms comprised of calcareous, medium textured colluvium (Colluvium C) in the Alpine Ecoregion of Banff and Jasper. It occurs on or below steep, rocky walls in areas that are geologically dominated by calcareous strata.

Eutric and Melanic Brunisols, Regosols, and Humic Regosols characterize the soil component of BS. These well drained soils reflect the calcareous, medium textured parent material. The vegetation component is characterized by mountain avens tundra. Only one Ecosite (BS1) is recognized within the BS Ecosection. Its general features are outlined in Table 125. Figs. 51 and 53, show schematically the physiographic position of BS1 on the landscape in relation to other Ecosites.

BS1 - BOW SUMMIT 1 ECOSITE

Ecosite Concept

The Alpine Ecosite, BS1, occurs on blankets and veneers consisting of calcareous, medium textured colluvium (Colluvium C) overlying bedrock on steep valley walls. The soil component is dominated by Orthic Eutric Brunisols, Orthic Melanic Brunisols, Orthic Regosols, and Orthic Humic Regosols. The vegetation component is dominated by the mountain avens-snow willow-moss campion (H1) v.t.

Geomorphology

The BS1 Ecosite occurs on blankets and veneers consisting of calcareous, medium textured colluvium (Colluvium C) overlying inclined bedrock on steep valley walls. Underlying bedrock is predominantly calcareous strata. Colluviation, including soil creep and avalanching, occurs locally. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically and are most abundant on BS1 tracts of western Banff and southwestern Jasper. Erosional and colluvial processes have obliterated most

Table 125 General features of the Bow Summit (BS1) Ecosite.

Ecosite	Landform	Soils	Vegetation
BS1	Colluvium C; blanket, veneer	Eutric Brunisol, Melanic Brunisol, Regosol, Humic Regosol	mountain avens tundra

of the evidence of these eolian veneers. Rubble, without fine earth material for soil development, is common on some BS1 tracts, particularly those occurring below steep rock walls. Solifluction and cryoturbation are common modifying features of BS1.

Topographically, BS1 displays long, linear, inclined slopes commonly ranging from 45 to 100%. Tracts of BS1 with complex topography have linear slopes whose continuity is broken by one or more steep bedrock escarpments. Surface form is controlled by deposition and underlying bedrock. The colluvial material is usually shallowest (veneers) at the tops of slopes and deepens downslope. Colluvial veneers dominate BS1X tracts and bedrock exposures dominate tracts mapped as BS1+R.

Soils

Soil development and distribution on the BS1 Ecosite is affected by the degree of colluvia-

Table 126 Pedon (Alberta 1978 No. 25) description of an Orthic Melanic Brunisol of the BS1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC MELANIC BRUNISOL. SOIL MAP UNIT: NOTATION: BS1.

LOCATION: MILITARY GRID REF. 11 UMH 8790 8385; NTS MAP AREA 83C 3W.

CLIMATE: 2320 METERS ABOVE MEAN SEA LEVEL. STATION AT COLUMBIA ICEFLD HAS GOOD RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 2 DEG(C) AT 50 CM IN AUGUST, NO. 2 WAS 2 DEG(C) AT 20 CM IN AUGUST.

VEGETATION: VPN=SJ8096*VTN=L4-H4*.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFEPENTIATED, EOLIAN; PARENT MATERIAL 2: SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), COLLUVIAL, LIMESTONE; LANDFORM CLASSIFICATION: COLLUVIAL, INCLINED; SLOPE: 40% SIMPLE SLOPE OF CLASS 7 (31-45%), FACING NORTH, SITE AT UPPER SLOPE POSITION; SOIL MOISTURE AND DPAIHAGE: RAPIDLY DRAINED AND WELL DRAINED, RAPID SURFACE RUNOFF, SEEPAGE ABSENT, SLIGHT WATER EROSION; SLIGHTLY STONY; EXCEEDINGLY ROCKY.

SPECIAL NOTES: SSN=DA8086*APN=010-195*LFH=EV/CB/RI*

AH: 0 TO 10 CM, RANGE 7 TO 13 CM; MATRIX MOIST 7.5YR 3/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM, HORIZONTAL ROOTS; 10% ANGULAR GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BM: 10 TO 16 CM, RANGE 5 TO 8 CM; MATRIX MOIST 5YR 4/6, MATRIX MOIST 7.5YR 6/4; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM, VERTICAL ROOTS; 10% ANGULAR GRAVELLY COARSE FRAGMENTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

2CK: 16 TO 60 CM; MATRIX MOIST 10YR 5/3; COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; VERY FEW, VERY FINE, VERTICAL ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 60% ANGULAR GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
AH	6.9	7.70	
BM	7.2	3.50	34.8
2CK	7.6		93.5

CHEMICAL DATA (SURVEY)

	EXTRACT IRON (%)		EXTRACT ALUMINUM (%)	
HORIZON	1	2	1	2
AH				
BM	0.1		-.1	
2CK				

PHYSICAL DATA (SURVEY)

PARTICLE SIZE ANALYSIS

	% PASSING										% OF SAMPLE				
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
AH								4	8	12		78	10	
BM						1	1	4	13	19		71	10	
2CK	99			39	15	15	12	11	6	59		36	5	

PHYSICAL DATA

	MOISTURE STATUS (%)				ENGINEERING							
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AH		49.8	34.4										
BM													
2CK		8.5	1.1									12	

tion and humus incorporation at the surface and, to a lesser degree, by avalanching. Orthic Eutric Brunisols, Orthic Melanic Brunisols, Orthic Regosols, and Orthic Humic Regosols are the dominant soils. Orthic Eutric Brunisols occupy localities where Ah horizon development is weak and eluvial (Ae) horizon development is inhibited or destroyed. Orthic Melanic Brunisols and Orthic Humic Regosols occupy localities where humus accumulation in the upper sola is evident. Locally, colluviation has physically thickened surface organo-mineral horizons. Orthic Regosols occur where geomorphic activity is frequent and intense, such as sparsely vegetated rubbly sites.

Soils mapped in the BS1 Ecosite are well drained and their profile development reflect the influence of the calcareous, medium textured parent material. The Brunisolic soils have thin sola and weakly developed Bm or Bmk horizons. Orthic Melanic Brunisols and Orthic Humic Regosols have thick Ah horizons. Orthic Eutric Brunisols and Orthic Regosols may have thin Ah horizons. Cumulic Regosols and Cumulic Humic Regosols occur in minor amounts. Turbic soil phases occur occasionally on BS1 tracts. Lithic soil phases dominate tracts mapped as BS1X. A pedon illustrating Orthic Melanic Brunisols of BS1 is dscribed in Table 126 and shown in Color Plate 8. This pedon was sampled on a north slope above Sunwapta Pass on the Jasper side of the Banff-Jasper boundary. The upper solum of this pedon is developed in a mixture of Eolian material B and Colluvium C.

Vegetation

Distribution of vegetation on BS1 reflects the degree of colluvial activity, exposure, and elevation. The mountain avens-snow willow-moss campion (H1) v.t. is dominant. Mountain avens-kobresia-bearberry (H4) and heather-everlasting (L5) are accessory v.t.s. Small amounts of the white mountain heather-mountain avens-snow willow (L4) v.t. occur in late snow lie areas. Other v.t.s. in small amounts are saxicolous lichen (H12) and hairy wild rye-junegrass-bearberry (H14). Unvegetated portions asociated with rubbly colluvium and Regosolic soils on intensely active sites constitute up to 50% of tracts mapped as BS1, or up to 80% of BS1+T or BS1+CR tracts. A plot illustrating the mountain avens-snow willow-moss campion (H1) v.t. on BS1 is described in Table 127. Plate 93 shows the landscape and vegetation of BS1.

Discussion

In terms of landform surface expression, physiographic position, and vegetation cover, BS1 resembles the Redoubt 1 (RD1) and Tekarra 1 (TK1) Ecosites. However, RD1 occurs on colluvial landforms consisting of noncalcareous, medium textured colluvium (Colluvium B), TK1 occurs on noncalcareous, coarse textured colluvium (Colluvium A) rather than the calcareous colluvium associated with BS1. Also RD1 and TK1 differ because they have acidic soils. The Wildflower (WF) Ecosites are the Upper Subalpine counterparts to BS1.

Table 127 Stand (JC6025) illustrating the mountain avens-snow willow-moss campion (H1) v.t. of the BS1 Ecosite.

SHRUB LAYER	
Abies lasiocarpa	.5
HERB-DWARF SHRUB LAYER	
Anemone parviflora	.5
Carex nardina	02
Castilleja occidentalis	.5
Draba incerta	.5
Dryas octopetal a	70
Erigeron aureus	.5
Phyllodoce glanduliflora	01
Poa alpina	.5
Polygonum viviparum	.5
Silene acaulis	.5
Taraxacum lyratum	.5
Trisetum spicatum	.5
Potentilla sp.	.5
Selaginella densa	.5
BRYOID LAYER	
Bryum sp.	.5
Cetraria laevigata	.5
Cladonia sp.	01

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

BV - BOW VALLEY ECOSECTION

The Bow Valley (BV) Ecosection occurs on calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) in the Lower Subalpine portion of the Subalpine Ecoregion. Soils characterizing BV are Eutric Brunisols; the vegetation is either lodgepole pine or Engelmann spruce-subalpine fir forest.

The BV Ecosection is found most frequently and with greatest extent on the broadest valley floors throughout the Lower Subalpine in Banff and Jasper. Extensive areas are mapped in the Bow River valley between Johnston Creek and Village Lake Louise in Banff and in the Athabasca River valley in the Sunwapta and Chaba confluence area in Jasper.

Three Ecosites (BV1, BV2, BV3) are recognized mainly on differences in vegetation. Table 128 shows general features of the BV Ecosection. A representation of BV Ecosites on the landscape is presented in Fig. 33.

Landform genesis of the BV Ecosection can be compared to the presently actively aggrading glaciofluvial landform of the Pipestone 4 (PP4) Ecosite.

Figure 33 Landscape schematic showing the relationships of the Bow Valley (BV) Ecosites to other Ecosites.

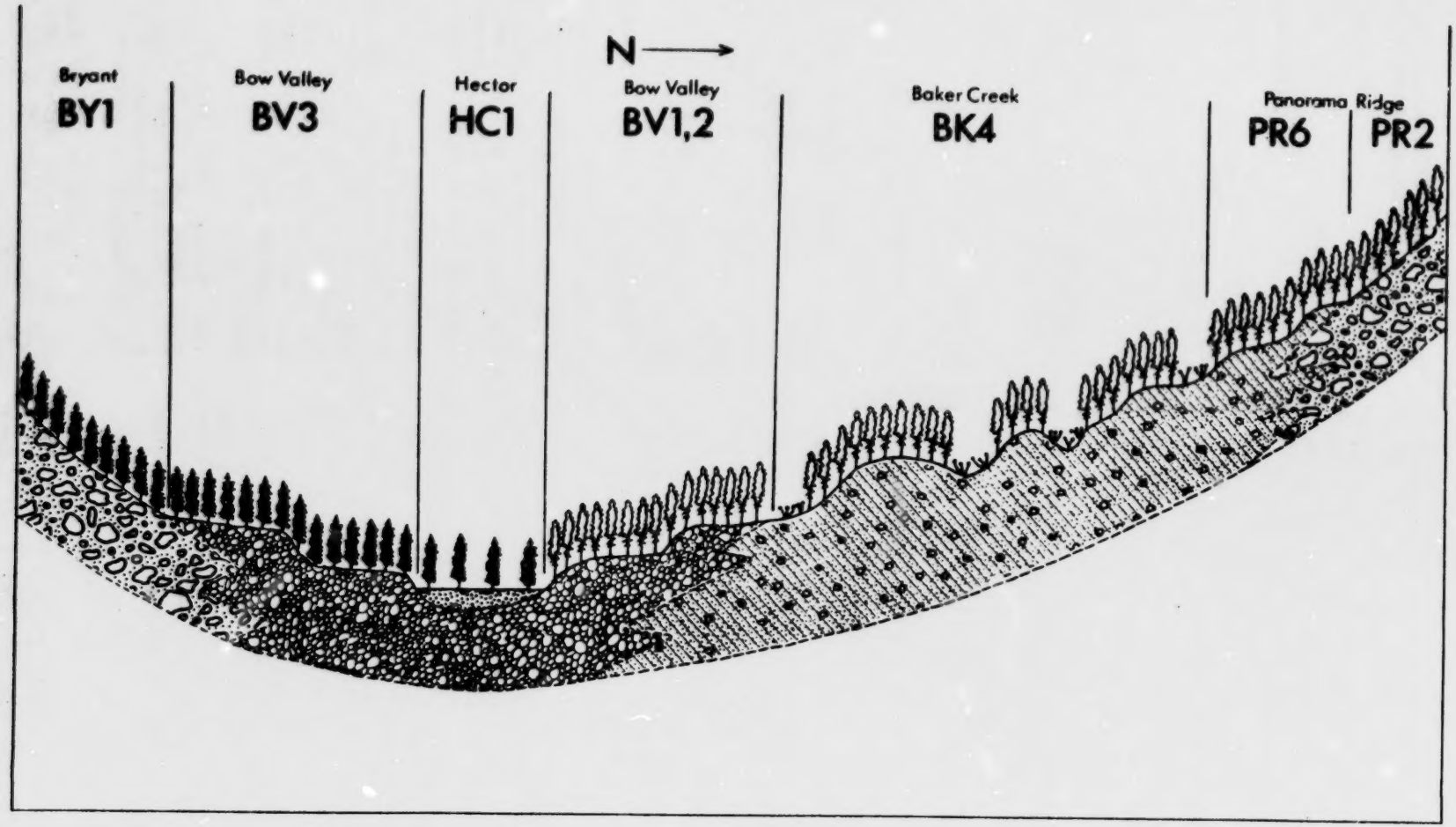


Table 128 General features of the Bow Valley (BV) Ecosites.

Ecosite	Landform	Soils	Vegetation
BV1	Glaciofluvial B; terrace	Eutric Brunisol	lodgepole pine/dwarf bilberry, lodgepole pine/buffaloberry
BV2	Glaciofluvial B; terrace	Eutric Brunisol	lodgepole pine/false azalea, lodgepole pine/Labrador tea
BV3	Glaciofluvial B; terrace	Eutric Brunisol	Engelmann spruce-subalpine fir forest

BV1 - BOW VALLEY 1 ECOSITE

Ecosite Concept

The BV1 Ecosite occurs on terraces of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) in the Lower Subalpine portion of the Subalpine Ecoregion. Orthic and Eluviated Eutric Brunisols are the dominant soils with lodgepole pine/dwarf bilberry (C9), lodgepole pine/buffaloberry/grouseberry (C18), and lodgepole pine/buffaloberry/twinflower (C19) as the major v.t.s. The BV1 Ecosite is the most extensive one of the BV Ecosection.

The BV1 Ecosite is found on floors and lower benchlands of broad valleys with gentle grades that once accommodated large volumes of glacial meltwater. Extensive tracts are mapped in the Bow River valley in Banff between Johnston Creek and Village Lake Louise, and adjacent to the Athabasca-Sunwapta confluence in Jasper.

Geomorphology

The BV1 Ecosite occurs on terraces of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B). Some tracts retain an irregular channeled surface (Eroded modifier, C.S.S.C. 1978b) as evidence of the braided streams that formed them during deglaciation. These areas have generally remained stable, usually accumulating a thin mantle of altered, medium textured eolian material (Eolian material B), especially in western Banff and southwestern Jasper. Material (slope wash) occasionally mantles portions of terraces abutting steeper gullied slopes.

Other modifications of the landform, since original deposition, have occasionally been produced by recent fluvial processes. Some modern streams have incised into the glaciofluvial material, bisecting the original landform. Others, emerging from steeper land, have fanned out spreading a mantle of recent fluvial material. The Bow River and its tributaries have effected these changes at several locations between Village Lake Louise and Johnston Creek in Banff.

Overall, tracts are mapped as having complex slopes. Within tracts, slopes between 1 and 15% are most common. Treads of the terraces make up the majority of the area and have gentle linear slopes. These contrast with the short steeper scarps between terrace levels. Some tracts have small amounts of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) with hummocky surface form. This material is more variable in texture and coarse fragment content than the usually massively bedded glaciofluvial material. Complex slopes also exist in the infrequent instances where aggradation occurred in an area of hummocky bedrock. Incomplete burial has left isolated bedrock knolls in some BV1 tracts in the vicinity of Village Lake Louise.

Soils

Long-term landform stability and consistent parent materials have resulted in uniform soil development on BV1. Soils are Orthic and Eluviated Eutric Brunisols. The taxonomic separation is based on the depth of the surface eluvial (Ae) horizon in these otherwise similar soils. Table 129 describes an Eluviated Eutric Brunisol sampled in the Athabasca River valley in Jasper that illustrates soils of BV1. The variable depth (0-5 cm) of the Ae horizon indicates that this pedon falls on the taxonomic boundary between Orthic and Eluviated Eutric Brunisols. It has an eolian-glaciofluvial parent material disconformity in the solum and a residual calcium carbonate content in the lower B horizon below this disconformity that is typical of soils of the Ecosite. However, the usual luvisolic tendency (increase in clay) of this B horizon is not well demonstrated here. The low extractable iron and aluminum values for the upper B horizons which have developed in the eolian material, indicate a weak weathering environment.

Table 129 Pedon (Alberta 1976 No. 63) description of an Eluviated Eutric Brunisol of the BV1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1976. SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: BV1.

LOCATION: MILITARY GRID REF. 11 UMJ 5200 2345; NTS MAP AREA 83C 12.

CLIMATE: 1290 METERS ABOVE MEAN SEA LEVEL.

VEGETATION: VPN=LC9180*VTN=C19*.

SOIL SITE: PARENT MATERIAL 1: CHEMICAL AND PHYSICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), EOLIAN, UNDIFFERENTIATED OR UNDETERMINED; PARENT MATERIAL 2: CHEMICAL AND PHYSICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), GLACIOFLUVIAL, MIXED AND CONGLOMERATE AND LIMESTONE AND QUARTZITE; LANDFORM CLASSIFICATION: GLACIO FLUVIAL, TERRACED; SLOPE: 1% SIMPLE SLOPE OF CLASS 2 (0.5-2%), FACING WEST, SITE AT MIDDLE POSITION, LEVEL MICROTOPOGRAPHY,300 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY; HUMUS-FORM: FIBRIMOR.

SPECIAL NOTES: SSN=WN6021*APN=015-061*BCU=BL*PCF=2CB(2)1GR,2CB(3)4GR,5CB(4)5GR,5CB(5)*LIME PENDANTS IN ZBM*AP DISCONTINUOUS*LFM=EV/FGT

LF: 2 TO 0 CM, RANGE 1 TO 5 CM; ABUNDANT, VERY FINE, HORIZONTAL ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 2 CM, RANGE 0 TO 5 CM; MATRIX MOIST 10YR 6/2; SILT LOAM; VERY WEAK, COARSE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, FINE AND MEDIUM, HORIZONTAL ROOTS; SHALY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BM: 2 TO 14 CM, RANGE 10 TO 22 CM; MATRIX MOIST 7.5YR 5/8, MATRIX MOIST 10YR 6/8; SILT LOAM; STRUCTURELESS STRUCTURE; VERY WEAK, VERY FINE TO FINE, GRANULAR SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, FINE AND MEDIUM, HORIZONTAL ROOTS; SHALY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

2BM: 14 TO 24 CM, RANGE 8 TO 12 CM; MATRIX MOIST 10YR 6/6, MATRIX MOIST 10YR 7/6; VERY GRAVELLY COARSE SANDY LOAM; SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE, VERTICAL ROOTS; GRAVELLY AND SHALY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2CK: 24 TO 60 CM; MATRIX MOIST 10YR 5/4, MATRIX MOIST 10YR 6/4; VERY GRAVELLY COARSE SANDY LOAM; SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, FINE, VERTICAL ROOTS; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; GRAVELLY AND SHALY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.4	42.28							
AE	4.5	1.78		11.5		2.3	0.5	0.1	0.1
BM	5.5	1.70		14.7		3.4	0.4	0.1	0.1
2BM	7.0	0.78	2.6						
2CK	7.4		26.6						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	-.1		0.1	
2BM	-.1		-.1	
2CK				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE					3	5	3	6	10	27		67	6	1
BM					8	14	5	4	6	37		60	3	0
2BM					16	22	12	7	5	62		29	9	3
2CK	99	61	37	21	13	30	16	9	4	72		24	4	1

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AE								
BM								
2BM								
2CK	0.0	0.0					11	03

Soils of BV1 are rapidly to well drained because of the pervious nature of the glaciofluvial material. Local seeps may affect both soils and vegetation at the margin of a tract where slopes break from steeper, adjoining, valley wall Ecosites. Terrace surfaces are generally high relative to the water table.

Turbic phases of BV1 soils occur sporadically throughout the landscape where windthrow from trees has disturbed the solum. This is most prevalent in tracts where materials have low coarse fragment content, such as on the BV1 tract adjacent to Kidney Lake in the Snake Indian River valley in Jasper. Lithic phases are absent because of the thickness of the glaciofluvial material that usually also overlies other unconsolidated materials.

Vegetation

The similar v.t.s, lodgepole pine/buffaloberry/grouseberry (C18) and lodgepole pine/buffaloberry/twinflower (C19), are dominant on BV1. The lodgepole pine/dwarf bilberry (C9) v.t. also occurs on BV1 in Banff, notable in the Eisenhower Junction vicinity in the Bow River valley. Lodgepole pine/juniper/bearberry (C3) is found on drier tracts in eastern Banff and Jasper where there is lower precipitation. Many BV1 tracts have been burned within the past century. Table 130 describes a plot sampled in the vicinity of the pedon in Table 129 and illustrates the C19 v.t. found on BV1. Plate 94 is a photograph of this plot area.

Table 130 Stand (LC9180) illustrating the lodgepole pine/buffaloberry/twinflower (C19) v.t. of the BV1 Ecosite.

TREE LAYER	
Pinus contorta	50
SHRUB LAYER	
Juniperus communis	05
Shepherdia canadensis	40
HERB-DWARF SHRUB LAYER	
Arnica cordifolia	.5
Arctostaphylos uva-ursi	05
Aster conspicuus	.5
Castilleja spp.	.5
Chimaphila umbellata	02
Cornus canadensis	02
Elymus innovatus	08
Fragaria virginiana	03
Goodyera repens	01
Linnaea borealis	20
Picea glauca	.5
Pinus contorta	.5
Pyrola asarifolia	01
Pyrola secunda	.5
Rosa acicularis	03
BRYOID LAYER	
Cladonia mitis	.5
Cladonia cenotea	.5
Cladonia cornuta	.5
Cladonia ecmocyna	01
Cladonia gonecha	01
Cladonia gracilis	.5
Cladonia phyllophora	.5
Cladonia pyxidata	01
Dicranum brevifolium	05
Drepanocladus uncinatus	.5
Hylocomium splendens	10
Peltigera aphthosa	05
Pleurozium schreberi	30
Polytrichum juniperinum	05
Ptilium crista-castrensis	05
Stereocaulon tomentosum	02
Barbilophozia lycopodioides	05
EPIPHYTES	
Bryoria fuscescens	.5
Cetraria chlorophylla	.5
Cetraria merrillii	.5
Cetraria pinastri	.5
Hypogymnia physodes	.5
Letharia vulpina	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5
Usnea subfloridana	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The BV1 Ecosite occurs on one of the most stable unconsolidated landforms in the parks. The valley floor position is remote from disturbances such as snow avalanching. The BV1 Ecosite does not occur complexed with Miscellaneous Landscapes; however, an extensive area of BV1 is mapped as burned in the lower Chaba River valley in Jasper.

In accessible areas, BV1 tracts are often disturbed by human activity. Borrow pits are common, especially along the transportation and utility corridors that traverse the gentler slopes of this Ecosite. At Village Lake Louise, the campground and much of the village itself are developed on BV1 tracts.

Local glaciofluvial terraces in tracts mapped as Panorama Ridge 6 (PR6) or Baker Creek 4 (BK4) may be identical to BV1. However, both of the former Ecosites are found on calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) rather than glaciofluvial landforms. Where BV1 is mapped adjacent to and in the Montane—Subalpine transition zone, it is very similar to its Montane counterpart, Athabasca 1 (AT1), but the latter has lodgepole pine forests more typical of the Montane. The Upper Subalpine counterpart, Nigel 1 (NG1), is distinguished by its Engelmann spruce-subalpine fir forest. Vegetation differences that distinguish BV1 from BV2 and BV3 are outlined in Table 128.

BV2 - BOW VALLEY 2 ECOSITE

Ecosite Concept

The BV2 Ecosite occurs on terraces of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) in the Lower Subalpine portion of the Subalpine Ecoregion. Eluviated Eutric Brunisols dominate the Ecosite, but some tracts may be primarily Orthic Eutric Brunisols. Lodgepole pine/false azalea/grouseberry (C20) and lodgepole pine/Labrador tea (C29) are the predominant v.t.s.

BV2 is found on floors and lower benchland of broad valleys with gentle grades that accommodated large volumes of glacial meltwater. Extensive tracts are mapped between Village Lake Louise and Kicking Horse Pass in Banff, and adjacent to the Rocky River confluence with the creek draining Jacques Lake in Jasper.

Geomorphology

The BV2 Ecosite occurs on terraces of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B). Some tracts retain an irregular channeled surface (eroded) as

evidence of the braided streams that formed them during deglaciation. These areas have generally remained stable, usually accumulating a thin mantle of altered, medium textured eolian material (Eolian material B), especially in western Banff.

Other landform modifications, since original deposition, have occasionally been produced by recent fluvial processes. Material (slope wash) occasionally mantles portions of terraces abutting steeper slopes that are gullied. Some modern streams have incised into the glaciofluvial material, bisecting the original landform. The stream draining Jacques Lake has bisected the BV2 on the Rocky River in Jasper.

Overall, tracts are usually mapped as having complex slopes. Within tracts, slopes between 1 and 15% are most common. Treads of the terraces have linear, gentle slopes and make up a majority of the area. These contrast with the short steeper scarps between terrace levels. Some tracts have small amounts of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) with hummocky surface form. This material is more variable in texture and coarse fragment content than the usually massively bedded glaciofluvial material. Complex slopes also exist in the infrequent instances where aggradation occurred in an area of hummocky bedrock. Incomplete burial has left isolated bedrock knolls in some BV2 tracts in the vicinity of Kicking Horse Pass in Banff.

Table 131 Pedon (Alberta 1975 No. 107) description of an Eluviated Eutric Brunisol of the BV2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: BV2.

LOCATION: MILITARY GRID REF. 11 UNG 5240 9960; NTS MAP AREA 82N 8E.

CLIMATE: 1640 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS GOOD RELEVANCE TO THE SOIL SITE.

VEGETATION: VPN=AW5177*VTN=C28*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), EOLIAN, UNDIFFERENTIATED OR UNDETERMINED; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), GLACIOFLUVIAL, UNDIFFERENTIATED OR UNDETERMINED; ORGANIC DEPOSIT IS 0.1 M; LANDFORM CLASSIFICATION: GLACIO FLUVIAL AND UNCONSOLIDATED AND UNDIFFERENTIATED. TERRACED AND UNDULATING; SLOPE: 1.5% COMPLEX SLOPE OF CLASS 2 (0.5-2%), FACING NORTHWEST, SITE AT UPPER SLOPE POSITION, SLIGHTLY ROUNDED MICROTOPOGRAPHY,30 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; NONSTONY; NONROCKY.

SPECIAL NOTES: SSN=BW5177*APH=403-008*PLU=15*PCF*1CB(2)1GR,1ST(3)4GR,2CB,2ST(4)4GR,3ST,2CB(5)*LF HORIZON CONTAINS OVER 90 PERCENT CHARCOAL*REPRESENTATIVE SITE * PROFILE*LFH*PGT*

LF: 5 TO 0 CM, RANGE 2 TO 8 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/1; MATERIAL COMPOSITION 5% NEEDLES, MODERATE DECOMPOSITION; ABUNDANT, FINE AND MEDIUM, RANDOM ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 3 CM, RANGE 0 TO 7 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/2, MATRIX MOIST 10YR 7/2; SANDY CLAY LOAM; WEAK, MEDIUM, PLATY STRUCTURE; FRIABLE CONSISTENCE; ABUNDANT, FINE, OBLIQUE ROOTS; COMMON, FINE PORES; COBBLY COARSE FRAGMENTS; BROKEN, ABRUPT HORIZON BOUNDARY.

BM: 3 TO 23 CM, RANGE 12 TO 30 CM; HORIZON MOIST; MATRIX MOIST 5YR 5/6; SANDY LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY WEAK, VERY FINE TO FINE, GRANULAR SECONDARY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE, OBLIQUE ROOTS; FEW, FINE PORES; STONY (BOULDERY) AND GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

2BCK: 23 TO 31 CM, RANGE 5 TO 11 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 4.5/4; GRAVELLY SANDY LOAM; VERY WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE, OBLIQUE ROOTS; VERY FEW, VERY FINE PORES; COBBLY AND STONY (BOULDERY) AND GRAVELLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2CK: 31 TO 90 CM; HORIZON MOIST; MATRIX MOIST 10YR 5.5/4; GRAVELLY ; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; STRONG EFFERVESCENCE; STRONGLY CALCAREOUS; HOMOGENEOUS ; COBBLY AND STONY (BOULDERY) AND GRAVELLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	3.4	54.60							
AE	4.4	1.30		10.2		2.8	0.3	-.1	0.1
BM	5.4	1.60		10.2		2.1	0.4	0.1	0.1
2BCK	6.7		20.6	6.7					
2CK	7.3		54.2						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	0.1		0.2	
2BCK				
2CK				

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE														
BM					9	11	11	18	9	47		26	27	14
2BCK					8	13	13	12	9	55		47	3	3
2CK					28	19	19	9	6	72		26	2	2

Soils

Long-term landform stability and consistent parent materials have resulted in uniform soil development on BV2. Soils are Eluviated Eutric Brunisols and Orthic Eutric Brunisols, the former dominant on most tracts. These soils are similar but separated taxonomically on thickness of the surface eluvial (Ae) horizon. Table 131 describes a pedon sampled in lower Bath Creek valley in Banff that illustrates soils of BV2. Color Plate 9 shows this pedon.

The variable depth (0-3 cm) of the Ae horizon indicates that this pedon falls on the boundary between Orthic and Eluviated Eutric Brunisols. It has an eolian-glaciofluvial parent material disconformity in the solum with the typical residual calcium carbonate and clay content increase in the upper layer of the second material. This pedon has an anomolously high clay content in the Ae horizon. The low extractable iron and aluminum values for the B horizon, developed in the eolian material, indicate a weak weathering environment.

Soils of BV1 are well drained because of the pervious nature of the glaciofluvial material. Local seeps may affect both soils and vegetation at the margin of a tract where slopes break from steeper, adjoining, valley wall Ecosites. Terraced surfaces are generally elevated relative to the water table.

Turbic phases of BV2 soils occur sporadically throughout the landscape where windthrow of trees has disturbed the solum. Lithic phases are absent because of the thickness of the glaciofluvial material that also generally overlies other unconsolidated materials.

Vegetation

The lodgepole pine/false azalea/grouseberry (C20) and lodgepole pine/Labrador tea (C29) v.t.s are dominant on BV2. The C20 v.t. is most extensive on BV2 tracts in the western portion of the parks, while C29 dominates eastern tracts. The lodgepole pine/feathermoss (C11) is an accessory v.t. also found on BV2. Table 132 describes a plot sampled at the same site as the pedon in Table 131 and illustrates the C20 v.t. found on BV2.

The v.t.s on BV2 resemble and are seral to the successionally mature Engelmann spruce-subalpine fir v.t.s (C13, C14, C30) that occur on the BV3 Ecosite. These mature v.t.s may be found locally on BV2 in places that have escaped fire in the past few centuries.

Discussion

The BV2 Ecosite occurs on one of the most stable unconsolidated landforms in the parks. The valley floor position is generally remote from disturbances such as snow avalanching. In Banff, one BV2 tract on a bench in Bath Creek valley below Mount Bosworth is avalanched. No tracts are mapped as burned. Vegetation in its earliest successional stages following fire is mapped as BV1B on this landform in the Lower Subalpine. BV2 does not occur as a complex with Miscellaneous Landscapes.

In accessible areas, BV2 tracts are often disturbed by human activity. Borrow pits are common, especially along the transportation and utility corridors that traverse the gentler slopes of this Ecosite, for instance, near Kicking Horse Pass in Banff.

Local glaciofluvial terraces in tracts of Panorama Ridge 6 (PR6) or Baker Creek 4 (BK4) may be identical to BV2. However, both of the former Ecosites are found on calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). Athabasca 1 (AT1) in the Montane, is similar to BV2, but occurs at lower elevations

Table 132 Stand (AW5177) illustrating the lodgepole pine/false azalea/grouseberry (C20) v.t. of the BV2 Ecosite.

TREE LAYER	
Pinus contorta	35
Picea engelmannii	02
TALL SHRUB LAYER	
Abies lasiocarpa	01
Picea engelmannii	06
SHRUB LAYER	
Abies lasiocarpa	02
Ledum groenlandicum	02
Menziesia glabella	12
Picea engelmannii	05
Shepherdia canadensis	02
HERB-DWARF SHRUB LAYER	
Arnica cordifolia	01
Calamagrostis rubescens	01
Cornus canadensis	05
Elymus innovatus	.5
Empetrum nigrum	01
Epilobium angustifolium	.5
Linnaea borealis	08
Pyrola asarifolia	.5
Pyrola secunda	.5
Vaccinium scoparium	20
BRYOID LAYER	
Alectoria spp.	.5
Barbilophozia hatcheri	09
Cladina spp.	04
Dicranum spp.	.5
Peltigera aphthosa	03
Pleurozium schreberi	70
Polytrichum juniperinum	01
Ptilium crista-castrensis	01

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

with lodgepole pine forests more typical of the Montane. The Upper Subalpine counterpart, Nigel 1 (NG1), has an Engelmann spruce-subalpine fir forest. Vegetation differences that distinguish BV2 from BV1 and BV3 are outlined in Table 128.

BV3 - BOW VALLEY 3 ECOSITE

Ecosite Concept

The BV3 Ecosite occurs on terraces of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) in the Lower Subalpine portion of the Subalpine Ecoregion. Orthic and Eluviated Eutric Brunisols are the dominant soils, with Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) the dominant v.t.s. It is the least extensive BV Ecosite.

The BV3 Ecosite is found on floors and lower benchland of broad valleys with gentle grades that accomodated large volumes of glacial meltwater. This Ecosite is not extensive in any one area, but occurs sporadically throughout both parks in remote or sheltered areas that have escaped fire for the past several hundred years.

Geomorphology

The BV3 Ecosite occurs on terraces of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B). Some tracts retain an irregular channeled surface (eroded) as evidence of the braided streams that formed them during deglaciation. These areas have generally remained stable, usually accumulating a thin mantle of altered, medium textured eolian material (Eolian material B), especially in western Banff and southwestern Jasper.

Recent fluvial material (slope wash) occasionally mantles portions of the terraces abutting steeper slopes that are gullied. Present watercourses often bisect or form one boundary of BV3 tracts.

Overall, tracts are usually mapped as having complex slopes. Within tracts, slopes between 1 and 15% are most common. Treads of the terraces make up a majority of the area, and have linear gentle slopes. These contrast with the short steeper scarps between terrace levels. Some tracts have small amounts of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) with hummocky surface form.

Soils

Long-term landform stability and consistent parent materials have resulted in uniform soil development. Soils are both Eluviated Eutric Brunisols and Orthic Eutric Brunisols with the former dominant on most tracts. These soils are similar but separated taxonomically on the thickness of the surface eluvial (Ae) horizon.

The pedon description contained in the BV2 description, Table 131, serves to illustrate soils of the BV3 Ecosite. A similar pedogenic environment is assumed for both of these Ecosites.

Soils of BV3 are well drained because of the pervious nature of the glaciofluvial material. Local seeps may affect both soils and vegetation at the margin of a tract where slopes break from steeper, adjoining, valley wall Ecosites. Terraced surfaces are generally elevated relative to the water table.

Turbic phases of BV3 soils occur sporadically throughout the landscape where windthrow of trees has disturbed the solum. Lithic phases are absent because of the thickness of the glaciofluvial material that also generally overlies other uncondolidated materials.

Vegetation

The successionally mature forests on BV3 reflect the stability of this Ecosite. Tracts are dominated by Engelmann spruce-subalpine fir/feathermoss (C13) close to the Continental Divide and by Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) to the east. Table 133 describes a plot, sampled in the Chaba River valley in Jasper near Fortress Lake, that illustrates vegetation of the BV3 Ecosite.

This plot and its setting illustrate well the stability of BV3. The Chaba River valley recently experienced an extensive burn. Perhaps fortuitously, but more probably because it is isolated from other forest stands, this tract escaped the nearby burn. This plot also illustrates that C13 on BV3 tracts close to the Continental Divide often contains elements of the Engelmann spruce-subalpine fir/false azalea (C14) v.t.

The C13 v.t. also grades to the similar Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t. from west to east. For instance, C31 is found on BV3 tracts in the Red Deer River valley in Banff.

Discussion

The BV3 Ecosite occurs on one of the most stable unconsolidated landforms in the parks. The valley floor position is generally remote from disturbances such as snow avalanching. Though not necessarily the rule, some BV3 tracts also are found in positions less subject to fire than tracts of other BV Ecosites with all other factors equal. Probably because of

Table 133 Stand (IC6100) illustrating the Engelmann spruce-subalpine fir/feathermoss (C13) v.t. of the BV3 Ecosite.

TREE LAYER	
Abies lasiocarpa	06
Picea engelmannii	40
TALL SHRUB LAYER	
Abies lasiocarpa	02
Picea engelmannii	.5
SHRUB LAYER	
Abies lasiocarpa	10
Ledum groenlandicum	.5
Menziesia glabella	02
Picea engelmannii	.5
Rhododendron albiflorum	01
Sorbus scopulina	.5
HERB-DWARF SHRUB LAYER	
Cornus canadensis	05
Linnaea borealis	03
Pyrola secunda	01
Pyrola virens	.5
Vaccinium membranaceum	02
BRYOID LAYER	
Hylocomium splendens	20
Peltigera aphthosa	02
Pleurozium schreberi	30
Polytrichum commune	.5
Ptilium crista-castrensis	20
Barbilophozia hatcheri	05

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 05 INDICATES THE SPECIES WAS PRESENT.

a positive correlation between man's presence and fire, BV3 is not found in any readily accessible areas. The BV3 Ecosite does not occur as a complex with Miscellaneous Landscapes.

Local glaciofluvial terraces in tracts of Bryant 4 (BY4) or Baker Creek 6 (BK6) may be identical to BV3. However, both of these Ecosites are found on calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). The Montane counterpart of BV3, Athabasca 1 (AT1), is distinguished because is has lodgepole pine forest v.t.s. Nigel 1 (NG1), the Upper Subalpine counterpart of BV3, is very similar but is forested with Engelmann spruce-subalpine fir forest v.t.s typical of the Upper Subalpine. Vegetation differences that distinguish BV3 from BV1 and BV2 are outlined in Table 128.

BY - BRYANT ECOSECTION

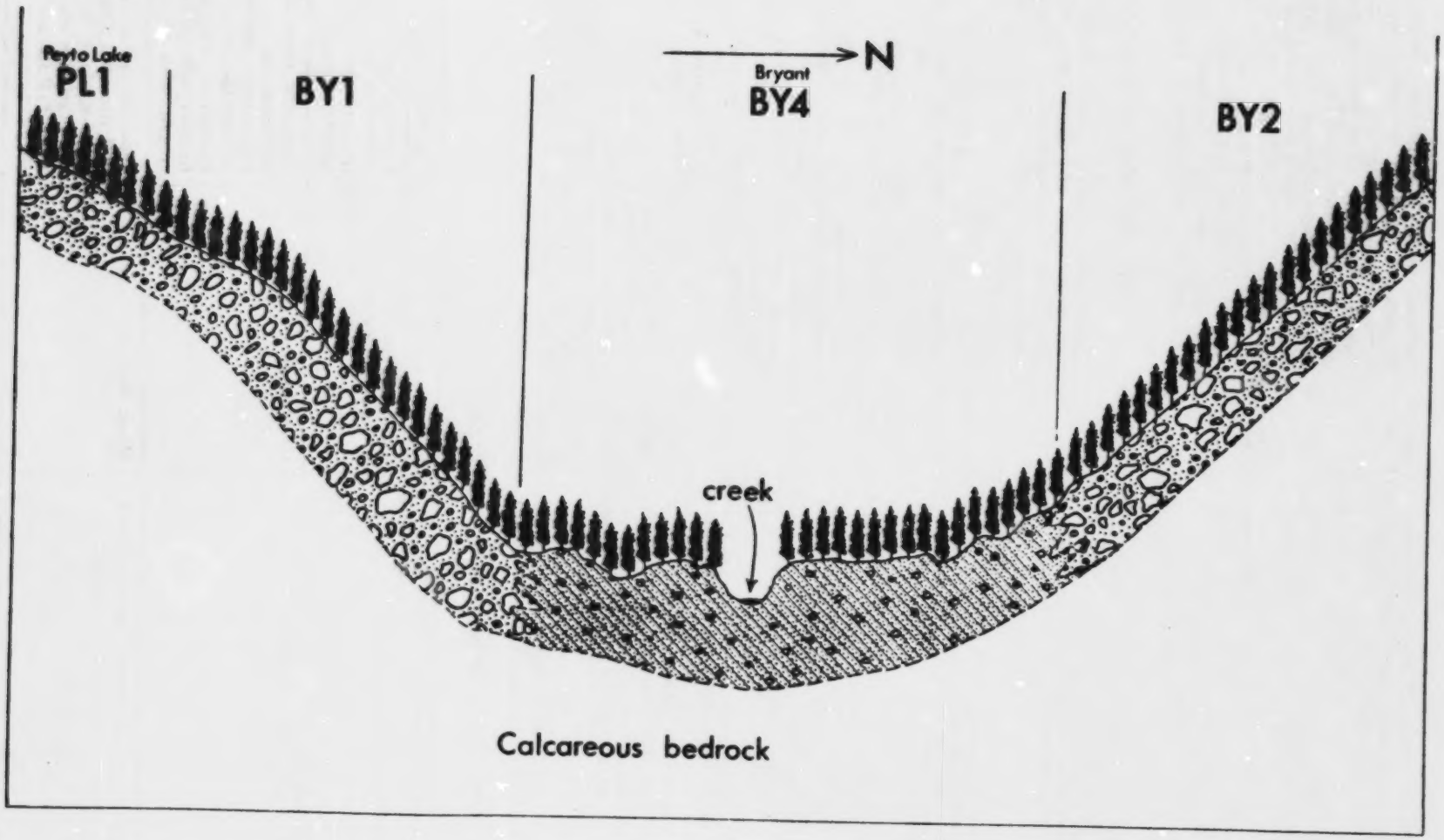
The Bryant Ecosection is one of the most extensive in Banff and Jasper and encompasses glacial landforms comprised of calcareous, medium textured till (Till C) or calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) throughout the Lower Subalpine portion of the Subalpine Ecoregion. It occurs primarily on valley walls, shoulders and floors, including benchlands on broad valley floors, and is associated with calcareous bedrock strata.

The dominant soils, Eutric Brunisols, are moderately developed and reflect the calcareous, medium to variably textured parent materials and cool, moist, climax, Engelmann spruce-subalpine fir forests that dominate the vegetation component of the landscape. There are three Bryant Ecosites. As outlined in Table 134, different vegetation groups distinguish BY1 from BY2 whereas BY4 is separated from the first two by geomorphic material differences. Fig. 34 shows the relative positions of the Bryant Ecosites. Only occasionally does this combination dominate a valley as shown in the diagram. The Peyto Lake Ecosection is the Upper Subalpine counterpart of Bryant.

Table 134 General features of the Bryant (BY) Ecosites.

Ecosite	Landform	Soils	Vegetation
BY1	Till C; blanket	Eutric Brunisol > Humo-Ferric Podzol	Engelmann spruce-subalpine fir/false azalea, Engelmann spruce-subalpine fir/tall bilberry/liverwort
BY2	Till C; blanket	Eutric Brunisol	Engelmann spruce-subalpine fir/feathermoss, Engelmann spruce-subalpine fir/Labrador tea/crowberry, Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss
BY4	Ice Contact Stratified Drift B; blanket, hummocky	Eutric Brunisol	Engelmann spruce-subalpine fir/feathermoss, Engelmann spruce-subalpine fir/false azalea, Engelmann spruce-subalpine fir/Labrador tea/crowberry

Figure 34 Landscape schematic showing the relationship of the Bryant (BY) Ecosites to other Ecosites.



BY1 - BRYANT 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite BY1, occurs on morainal blankets consisting of calcareous, medium textured till (Till C) overlying inclined bedrock on valley walls. Veneers of altered, medium textured eolian material (Eolian material B) occur extensively, and significantly influence soil development. Consequently BY1 exhibits a soil pattern in which Eluviated Eutric Brunisols are dominant, Orthic Eutric Brunisols and Orthic Humo-Ferric Podzols subdominant. Vegetation cover is dominated by the Engelmann spruce-subalpine fir/false azalea (C14) and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s. The C14 v.t. is usually most abundant but some BY1 tracts are dominated by C21.

The BY1 Ecosite is usually found on northerly aspects in two distinct areas of the western Banff and Jasper. The western Banff - southwestern Jasper area corresponds to the extensive distribution of Eolian material B. The northwestern Jasper area, north of the range of *Vaccinium scoparium*, has significant amounts of the C21 v.t. The BY1 Ecosite is especially common in the Icefields area of Banff and Jasper where the calcareous glacial materials are derived from the carbonate-dominated upper Main Ranges stratigraphic column. Little BY1 is found in west-central Jasper because of extensive non-calcareous Lower Cambrian and Precambrian strata. The BY1 Ecosite occurs sporadically in eastern portions of Banff and Jasper.

Geomorphology

The BY1 Ecosite is typified by morainal blankets consisting of calcareous, medium textured till (Till C) overlying inclined bedrock on valley walls. Surface veneers of altered, medium textured eolian material (Eolian material B) are extensively distributed over BY1 tracts of western Banff and southwestern Jasper, sporadically distributed elsewhere. Colluvium derived from till and/or fractured bedrock is found occasionally on the steepest portions of the landscape. Calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) occurs occasionally.

Topographically, the BY1 Ecosite displays long linear slopes consisting of till mantling the inclined bedrock that forms valley walls. Slopes are normally 15 to 70% and are often dissected by subparallel gullies oriented perpendicular to the contour. Small fluvial fans and aprons emanating from gully mouths along valley bottoms or other major slope breaks may be included in BY1 tracts. Tracts of BY1 situated at valley confluences, on valley shoulders, on failed slopes, and occasionally along valley floors often display morainal landforms with irregular (5-45% complex slopes) topography. These landforms include morainal blankets and veneers overlying ridged and hummocky bedrock and the relatively deep till of hummocky moraines. Morainal veneers, also occasionally found on inclined slopes, dominate on BY1X tracts. Bedrock outcrops occur occasionally on all types of terrain and are relatively common on BY1+R tracts. Patches of colluvium forming blankets and veneers occur occasionally on the steepest terrain, particularly below bedrock escarpments.

Soils

Eluviated Eutric Brunisols are the dominant soils of the BY1 Ecosite. Orthic Eutric Brunisols and Orthic Humo-Ferric Podzols are subdominant. These three groups are intimately associated on the predominantly well to moderately well drained terrain and reflect, in their development, the Eolian material B veneers overlying calcareous till. They usually have relatively well developed Bm, Bf, or podzolic Bf horizons above the parent material disconformity. Immediately below are found relatively weakly expressed Bm or Btj horizons that sometimes exhibit a clay increase. This development is accompanied by a pronounced pH increase from the upper to lower solum. Across some portions of the landscape Ae horizons are weakly expressed or have been destroyed by recent surface modification processes such as avalanching, gullying, windthrow of trees, or shallow surface colluviation. Soils with Bhf and podzolic Bhf horizons occur occasionally. Some gullies and depressional localities contain seeps where wet soils are found. Orthic and Cumulic Regosols occur on steep, colluviating portions of the landscape. Lithic soil phases are not common except on BY1X tracts where they dominate. A pedon illustrating Eluviated Eutric Brunisols of the BY1 Ecosite is described in Table 135 and shown in Color Plate 10.

Vegetation

The BY1 Ecosite is dominated by the Engelmann spruce-subalpine fir/false azalea (C14) and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s. Overall, C14 is more abundant but some BY1 tracts, particularly those located in northern Jasper and along the Continental Divide, are dominated by C21. The accessory v.t., Engelmann spruce-subalpine fir/feathermoss (C13), is often found near valley bottoms on more gently sloping lower slopes below C14 or C21 dominated valley walls. If large enough, these valley bottom localities are mapped as BY2.

Wet v.t.s such as Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14) are

Table 135 Pedon (Alberta 1978 No. 38) description of an Eluviated Eutric Brunisol of the BY1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: BY1.

LOCATION: MILITARY GRID REF. 11 UBN 1680 5320: NTS MAP AREA 82N 15N.

CLIMATE: 1800 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VRN=,ES1ES=VTH=C1A=.

SOIL SITE: PARENT MATERIAL 1: COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN; PARENT MATERIAL 2: SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL); LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 34% SLOPE OF CLASS 7 (31-45%), FACING NORTH, SITE AT UPPER SLOPE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,206 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY.

SPECIAL NOTES: SBH=TA81446*APN=010-203*PCF*2BR(3-4)46R,3CB,1ST(5)36R,2CB,2ST(6)=RLU=15=DATE=SEPT. 18,1978=LFH=EV/YB/BI=

LF: 15 TO 0 CM, RANGE 11 TO 17 CM; MATRIX MOIST 10YR 2/2; ABUNDANT, VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AE: 0 TO 5 CM, RANGE 4 TO 11 CM; MATRIX MOIST 10YR 6/1; SILT LOAM; WEAK, COARSE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; COMMON, FINE AND MEDIUM PORES; IRREGULAR, ABRUPT HORIZON BOUNDARY.

BM1: 5 TO 12 CM, RANGE 3 TO 16 CM; MATRIX MOIST 5YR 4/6; SILT LOAM; WEAK, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; COMMON, FINE AND MEDIUM PORES; 10% GRAVELLY COARSE FRAGMENTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

BM2: 12 TO 19 CM, RANGE 8 TO 11 CM; MATRIX MOIST 10YR 7/6; SILT LOAM; VERY WEAK, MEDIUM, PLATY STRUCTURE; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, MEDIUM ROOTS; COMMON, FINE AND MEDIUM PORES; 10% GRAVELLY COARSE FRAGMENTS; BROKEN, CLEAR HORIZON BOUNDARY.

2BCK: 19 TO 41 CM, RANGE 13 TO 30 CM; MATRIX MOIST 10YR 4/4; SILT LOAM; WEAK TO MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FIRM CONSISTENCE; FEW, MEDIUM ROOTS; COMMON, FINE AND MEDIUM PORES; STRONG EFFERVESCENCE; STRONGLY CALCAREOUS; 40% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2CK: 41 TO 80 CM; MATRIX MOIST 10YR 5/3; GRAVELLY SILT LOAM; WEAK TO MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE PSEUDO: STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; FIRM CONSISTENCE; VERY FEW, MEDIUM ROOTS; FEW, FINE AND MEDIUM PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 30% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG
LF	4.6	44.00			
AE	5.4	1.00		7.0	
BM1	5.5	3.30		30.0	
BM2	5.2	1.10		29.0	
2BCK	6.9		22.0		
2CK	7.1		75.0		

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM1	0.2		0.2	
BM2	0.1		0.2	
2BCK				
2CK				

PHYSICAL DATA (SURVEY)

PARTICLE SIZE ANALYSIS

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF															
AE										13		75	2		
BM1										24		67	9		
BM2										16		76	8		
2BCK										27		58	15		1.68
2CK		99			81					35		57	8		1.78

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	ENGINEERING SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE		8.5	1.0										
BM1													
BM2		10.0	0.1										
2BCK													
2CK		13.0	3.0			0.0	0.0					49	97

associated with seeps. Snow avalanche v.t.s such as subalpine fir-willow (S2) occur on avalanched portions of BY1. Fire affected vegetation in which spruce rather than pine is regenerating occurs in some areas (eg. lower Allenby Creek valley in Banff). A stand illustrating the C14 v.t. of the BY1 Ecosite is described in Table 136. This stand is located about 13 km northwest of the pedon sample site described above (Table 135).

Table 136 Stand (JD7021) illustrating the Engelmann spruce-subalpine fir/false azalea (C14) v.t. of the BY1 Ecosite.

TREE LAYER	
Abies lasiocarpa	05
Picea engelmannii	35
Pinus contorta	05
TALL SHRUB LAYER	
Abies lasiocarpa	05
Picea engelmannii	05
SHRUB LAYER	
Abies lasiocarpa	05
Juniperus communis	02
Ledum groenlandicum	.5
Menziesia glabella	70
Picea engelmannii	03
Rhododendron albiflorum	.5
HERB-DWARF SHRUB LAYER	
Arnica cordifolia	05
Aster ciliolatus	.5
Cornus canadensis	02
Elymus innovatus	08
Empetrum nigrum	10
Pyrola secunda	.5
Solidago multiradiata	.5
Vaccinium myrtilloides	20
Vaccinium scoparium	15
BRYOID LAYER	
Cladonia ecmocyna	.5
Dicranum fuscescens	03
Dicranum scoparium	02
Drepanocladus uncinatus	05
Hylocomium splendens	15
Peltigera aphthosa	08
Peltigera canina	.5
Pleurozium schreberi	25
Pohlia nutans	.5
Ptilium crista-castrensis	15
Rhytidiopsis robusta	.5
Stereocaulon tomentosum	.5
Barbilophozia lycopodioides	05
Blepharostoma tricophyllum	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The BY1 Ecosite is the most extensive Bryant Ecosite of the Main Ranges although BY2 and BY4 may be associated in some areas on valley floors and southerly aspects. The BY1 distribution roughly corresponds to the predominant distribution of Eolian material B and the C14 and C21 v.t.s.

Rather specific vegetation differences differentiate BY1 from BY2; landform and genetic materials differentiate BY1 from BY4 (Table 134). The Moraine Lake 1 (ML1) and Cavell 2 (CA2) Ecosites resemble BY1 in terms of topographic distribution, landform surface expression, and vegetation cover. The ML1 Ecosite is differentiated because it occurs on morainal landforms consisting of noncalcareous, coarse textured till (Till A), and CA2 because it occurs on noncalcareous, medium textured till (Till B). Both ML1 and CA2 are dominated by Dystric Brunisols. The ML1 soils have significantly thicker sola.

BY2 - BRYANT 2 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, BY2, occurs on morainal blankets consisting of calcareous, medium textured till (Till C) overlying inclined bedrock on valley walls. Orthic and Eluviated Eutric Brunisols are the dominant soils. Vegetation cover is dominated by the Engelmann spruce-subalpine fir/feathermoss (C13), Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30), and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t.s. The C13 v.t. is most abundant but some BY2 tracts are dominated by C30 or C31.

The BY2 Ecosite is usually found in the Front Ranges of Banff and Jasper. Some areas of the Main Ranges have tracts of BY2 on valley floors and southerly aspects.

Geomorphology

The BY2 Ecosite is typified by morainal blankets of calcareous, medium textured till (Till C) overlying inclined bedrock on valley walls. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically. Colluvium consisting of till and/or fractured bedrock is found occasionally on the steepest portions of the landscape. Calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) occurs occasionally.

Topographically, the BY2 Ecosite displays long linear slopes consisting of till mantling the inclined bedrock that forms valley walls. Slopes are normally 15 to 70%. These slopes are often dissected by subparallel narrow ravines oriented perpendicular to the contour. Small fluvial fans and aprons emanating from gully mouths along the valley bottoms or other major slope breaks may be included in BY2 tracts. Tracts of BY2 situated along valley floors, on valley shoulders, at valley confluences, and on failed slopes often display morainal landforms with irregular (5 - 45%

Table 137 Pedon (Alberta 1979 No. 91) description of an Orthic Eutric Brunisol of the BY2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: BY2.

LOCATION: MILITARY GRID REF. 11 UNG 9930 8720; NTS MAP AREA 820 SE.

CLIMATE: 1720 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS MODERATE RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JD9082*VTH=C31*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL); LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 30% SIMPLE SLOPE OF CLASS 7 (31-45%), FACING SOUTHWEST. SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,300 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, SLOWLY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY.

SPECIAL NOTES: SSN=WT9150*APN=010-159*RLU=15*PCF=2GR,1CB(2)3GR,3CB,1ST(3-6)*LFH=EV/MB/RI*DATE=SEPT.5,1979*

LF: 9 TO 0 CM, RANGE 8 TO 12 CM; MATRIX MOIST 10YR 2/2; ABUNDANT, COARSE, HORIZONTAL ROOTS; SMOOTH, CLEAR HORIZON BOUNDARY.

AB: 0 TO 8 CM, RANGE 7 TO 11 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 6/4; SILT LOAM; VERY WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MEDIUM AND COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

2BTJ: 8 TO 21 CM, RANGE 11 TO 14 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6; LOAM AND CLAY LOAM; MODERATE TO STRONG, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FIRM CONSISTENCE; FEW, FINE AND MEDIUM ROOTS; FEW, VERY THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; SMOOTH, CLEAR HORIZON BOUNDARY.

2BCK: 21 TO 30 CM, RANGE 7 TO 11 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/3; LOAM; WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, MICRO AND VERY FINE AND FINE ROOTS; WEAK EFFERVESCENCE; STRONGLY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

2CK1: 30 TO 67 CM, RANGE 35 TO 40 CM; HORIZON MOIST; 10YR 4/2.5; LOAM; MODERATE TO STRONG, FINE, SUBANGULAR BLOCKY STRUCTURE PSEUDO; FRIABLE CONSISTENCE; VERY FEW, MICRO AND VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

2CK2: 67 TO 90 CM; HORIZON MOIST; 10YR 4.5/2; LOAM; STRONG, MEDIUM TO COARSE, ANGULAR BLOCKY STRUCTURE PSEUDO; FIRM CONSISTENCE; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.6	46.10							
AB	6.6	1.50	0.3	17.7		12.6	2.6	-.1	0.2
2BTJ	6.9	0.90	0.7	22.7		12.9	3.1	-.1	0.2
2BCK	7.2		10.4						
2CK1	7.4		46.5						
2CK2	7.5		46.5						

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF															
AB															
2BTJ										31		55	14		
2BCK										28		43	27		
2CK1										36		46	18		
2CK2	99	79	65	60						37		46	17		
										47		41	12		2.20

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AB								
2BTJ								
2BCK								
2CK1								
2CK2	13.0	17.0					24	18

complex slopes) topography. These landforms include morainal blankets and veneers overlying ridged and hummocky bedrock and the relatively deep till of hummocky moraines. Morainal veneers, also occasionally found on inclined slopes, are dominant on tracts mapped as BY2X. Bedrock outcrops occur occasionally on all types of terrain and are relatively common on BY2+R tracts.

Soils

The soils of the BY2 Ecosite are dominated by Orthic and Eluviated Eutric Brunisols. These well drained soils have B horizons that range from the rudimentary textural horizons frequently associated with weathering of calcareous till to the comparatively advanced Bm and Bf horizons associated with local occurrences of altered, medium textured eolian material (Eolian material B). Orthic and Brunisolic Gray Luvisols, and Orthic Humo-Ferric Podzols occur in minor amounts. Soils with luvisolic tendencies are especially evident on the drier slopes of eastern Banff and Jasper. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly expressed in the absence of Eolian material B. In some localities Ae horizons have been destroyed by recent surface modification processes such as avalanching, gullying, windthrow of trees, or shallow surface colluviation. Some gullies and depressional localities contain seeps where wet soils are found. Orthic and Cumulic Regosols occur on steep, colluviating portions of the landscape. Lithic soil phases are not common except on BY2X tracts where they dominate.

A pedon illustrating Orthic Eutric Brunisols of the BY2 Ecosite is described in Table 137 and shown in Color Plate 11. This pedon has a very thin eolian veneer and represents soils (of the BY2 Ecosite) with luvisolic tendencies occurring on relatively dry southwest aspects in eastern Banff. As in this case, the Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t. is often associated with this kind of soil development on BY2. The relatively dark color of the Ck horizons is attributable to incorporation of material derived from Mesozoic strata.

Vegetation

The BY2 Ecosite is dominated by the Engelmann spruce-subalpine fir/feathermoss (C13), Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30), and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t.s. Overall, C13 is the most abundant v.t., but some BY2 tracts are dominated by C30 or C31. Factors affecting distribution of C13 versus C30 are not understood. The C31 v.t. tends to be more common on southerly aspects in the eastern part of the Front Ranges. The BY2 tracts characterized by C31 v.t.s often have soils with luvisolic tendencies. This soil - vegetation association implies somewhat drier conditions than on other BY2 soil - vegetation combinations.

Table 138 Stand (JD9082) illustrating the Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t. of the BY2 Ecosite.

TREE LAYER	
Abies lasiocarpa	03
Pinus contorta	02
Picea engelmannii	20
TALL SHRUB LAYER	
Picea engelmannii	02
SHRUB LAYER	
Abies lasiocarpa	.5
Juniperus communis	.5
Picea engelmannii	02
Shepherdia canadensis	13
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	.5
Achillea millefolium	.5
Arnica cordifolia	03
Aster ciliolatus	01
Aster conspicuus	03
Calypso bulbosa	.5
Carex concinna	.5
Cornus canadensis	08
Elymus innovatus	60
Epilobium angustifolium	01
Fragaria virginiana	01
Linnaea borealis	15
Mitella nuda	.5
Poa palustris	.5
Pyrola secunda	01
Rosa acicularis	.5
Senecio indecorus	.5
Vaccinium scoparium	01
Zygadenus elegans	.5
Equisetum scirpoides	.5
BRYOID LAYER	
Cladonia bacillaris	.5
Cladonia bacilliformis	.5
Dicranum acutifolium	.5
Drepanocladus uncinatus	.5
Hylocomium splendens	65
Peltigera aphthosa	02
Pleurozium schreberi	10
Ptilium crista-castrensis	01
EPIPHYTES	
Bryoria lanestris	.5
Bryoria fuscescens	.5
Hypogymnia enteromorpha	.5
Hypogymnia physodes	.5
Letharia vulpina	.5
Parmelia sulcata	.5
Parmeliopsis ambigua	.5
Usnea alpina	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Small patches of Engelmann spruce-subalpine fir/false azalea (C14) and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) occasionally occur on northerly aspects of some tracts. Wet v.t.s such as Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14) are associated with seeps. Snow avalanche v.t.s. such as subalpine fir-willow (S2) occur on avalanched portions of BY2 although the incidence of avalanching is less on BY2 than BY1. Fire affected vegetation in which spruce rather than pine is regenerating occurs in some areas (e.g. Upper Dormer Creek valley in Banff).

A stand representing vegetation of the pedon sample site described above (Table 137) and illustrating the C31 v.t. of BY2 is described in Table 138. The lower layers of this stand are shown in Plate 95. This stand has higher cover of *Shepherdia canadensis* and *Elymus innovatus* than the C31 central concept.

Discussion

The BY2 Ecosite is the dominant Bryant Ecosite of the Front Ranges although BY4 on valley floors and BY1 on northerly aspects may be associated in some areas.

Rather specific vegetation differences differentiate BY2 from BY1, landform genetic materials differentiate BY2 from BY4 (Table 134). The Moraine Lake 1 (ML1) and Cavell 2 (CA2) Ecosites resemble BY2 in terms of physiographic position, landform surface expression, and vegetation cover. However, ML1 occurs on morainal landforms consisting of noncalcareous, coarse textured till (Till A), and CA2 occurs on noncalcareous, medium textured till (Till B). Both ML1 and CA2 are dominated by Dystric Brunisols. The ML1 soils have significantly thicker sola.

BY4 - BRYANT 4 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, BY4, occurs on glacial landforms consisting of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). Inclined surfaces reflect the underlying bedrock. Hummocky surfaces reflect either underlying bedrock or deposition. The BY4 Ecosite is generally confined to valley floors including benchlands on broad valley floors and to lower valley wall slopes. BY4 is characterized by a soil pattern in which Eluviated Eutric Brunisols are dominant, Orthic Eutric Brunisols are subdominant. Vegetation cover is dominated by the Engelmann spruce-subalpine fir/feathermoss (C13), Engelmann spruce-subalpine fir/false azalea (C14) and Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) v.t.s. The C13 v.t. is most abundant but some BY4 tracts are dominated by C14 or C30. The BY4 Ecosite occurs in both Front and Main Ranges.

Geomorphology

The BY4 Ecosite is typified by glacial landforms consisting of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). Surficial veneers of altered, medium textured eolian material (Eolian material B) are most extensive on BY4 tracts located in western Banff and southwestern Jasper and less extensive elsewhere. Calcareous, medium textured till (Till C) often underlies the ice-contact stratified material.

Topographically, the BY4 Ecosite displays irregularly shaped knolls and depressions of hummocky surfaces on valley floors and benchlands. Linear inclined slopes usually occur on lower valley walls above the valley floors. Bedrock control is responsible for the inclined slopes and sometimes for the hummocky surface expression. Occasionally, ridged surfaces that reflect underlying bedrock occur. The hummocky surface expression of ice contact deposits is often depositional in origin. Kettle-holes, kames, and eskers are outstanding depositional features that occur on some tracts mapped as BY4. In some BY4 tracts of lower valley wall slopes, hummocky depositional surfaces are superimposed upon inclined slopes that reflect the underlying bedrock surface. Failed slopes occur occasionally. Slopes commonly range from 5 to 45%. Erosional features, such as gullies on steep linear slopes and small glaciofluvial terraces, occur occasionally. Veneers of glacial drift and rock outcrops occur rarely except in BY4+R tracts where rock escarpments are relatively common.

Soils

Soils that characterize the BY4 Ecosite are dominated by Eluviated Eutric Brunisols. Orthic Eutric Brunisols are subdominant. These well drained soils have B horizons that range from the rudimentary textural horizons frequently associated with weathering of calcareous glacial material to the comparatively advanced Bm and Bf horizons associated with altered, medium textured eolian material (Eolian material B). Orthic and Brunisolic Gray Luvisols, and Orthic Humo-Ferric Podzols occur in minor amounts. Soils with luvisolic tendencies are especially evident on the drier slopes of eastern Banff and Jasper. Orthic Eutric Brunisols are significantly less abundant associated with BY4 than with BY2, and approximately equal in abundance on BY4 and BY1. Greater abundance of Eolian material B and more gentle slopes are favorable for Ae development on BY4 as opposed to BY2. The BY1 Ecosite has more exten-

sive veneers of Eolian material B but its usually steeper slopes result in more surface disturbances than on BY4. Some depressional localities affected by seepage have wet soils. Regosolic soils and lithic soil phases occur rarely. A pedon illustrating Orthic Eutric Brunisols of the BY4 Ecosite is described in Table 139 and shown in Color Plate 12. Plate 96 shows the sample site. Vegetation at this site is a seral stage of the Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) v.t.

Table 139 Pedon (Alberta 1978 No. 81) description of an Orthic Eutric Brunisol of the BY4 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: BY4.

LOCATION: MILITARY GRID REF. 11 UNM 3910 3720; NTS MAP AREA 82N 16W.

CLIMATE: 1870 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VPN=JC8095= VTN=C29=.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EOLIAN; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND SANDY, EXTREMELY CALCAREOUS (>40% CACO3), GLACIOFLUVIAL AND MORAINAL (TILL), SEDIMENTARY; LANDFORM CLASSIFICATION: GLACIO MORAINAL AND FLUVIAL, BLANKET; SLOPE: 49% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING EAST, SITE AT LOWER SLOPE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,150 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; SLIGHTLY STONY; NONROCKY.

SPECIAL NOTES: SSN=WT8160=APN=810-207=RLU=15=PCF=1GR(2-3)SGP,1CB,1ST(4)3GR,2CB,1ST(5)3GR,3CB,1ST(6)=LFH=HFGB/BT=

LF: ~7 TO 0 CM, RANGE 6 TO 8 CM; MATRIX MOIST 5YR 3/1.5; ABUNDANT, VERY FINE AND FINE AND MEDIUM AND COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AEJ: 0 TO 2 CM, RANGE 0 TO 3 CM; MATRIX MOIST 10YR 6/3; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BM: 2 TO 9 CM, RANGE 6 TO 9 CM; MATRIX MOIST 10YR 5/8, MATRIX MOIST 7.5YR 5/8; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

2BCK: 9 TO 29 CM, RANGE 18 TO 22 CM; MATRIX MOIST 7.5YR 5/4; GRAVELLY SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; WEAK, FINE, GRANULAR SECONDARY STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 50% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2CK1: 29 TO 64 CM, RANGE 32 TO 38 CM; MATRIX MOIST 10YR 6/4; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE PSEUDO; WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE; FRIABLE CONSISTENCE; FEW, MICRO AND VERY FINE AND FINE ROOTS; MODERATELY PEROUS, COMMON, FINE PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 20% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2CK2: 64 TO 105 CM; MATRIX MOIST 10YR 6/3; LOAMY SAND; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 30% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.2	41.60							
AEJ									
BM	6.0	4.40	0.8	30.7		25.8	5.9	0.6	0.2
2BCK	7.4		77.1						
2CK1	7.6		93.3						
2CK2	7.6		99.7						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AEJ				
BM	0.1		0.1	
2BCK				
2CK1				
2CK2				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	% OF SAMPLE 50-2U SILT	% OF SAMPLE 2U CLAY	% OF SAMPLE 0.2U CLAY	BULK DENS G/CC
LF															
AEJ															
BM					1	1	1	3	16	22		76	2		
2BCK					8	6	4	8	9	35		54	11		
2CK1					10	9	6	9	7	41		52	7		1.90
2CK2	99	76	57	48	7	9	12	29	15	72		26	2		

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AEJ								
BM								
2BCK								
2CK1	12.0	15.0						
2CK2							12	67

Vegetation

The BY4 Ecosite is dominated by the Engelmann spruce-subalpine fir/feathermoss (C13), Engelmann spruce-subalpine fir/false azalea (C14), and Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) v.t.s. Overall, C13 is the most abundant v.t., but some BY4 tracts are dominated by C14 or C30. Factors affecting distribution of C13 versus C30 are not understood. The C14 v.t. tends to be more common on more steeply sloping, northerly facing BY4 tracts in the Main Ranges. The accessory v.t., Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31), is quite common on some BY4 tracts located in the eastern part of the Front Ranges. This v.t. is often associated with soils having luvisolic tendencies. Wet v.t.s. such as Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14) are associated with seepage in depressional localities. Snow avalanche v.t.s. such as subalpine fir-willow (S2) occur on avalanched portions of BY4 although the incidence of avalanching on BY4 is relatively low. Fire affected vegetation in which spruce rather than pine is regenerating occurs in some areas (e.g. upper Bryant Creek valley in Banff).

A stand illustrating the C30 v.t. of the BY4 Ecosite is described in Table 140. It is located <100 m downslope from the pedon sample site described above (Table 139). This stand has lower cover of *Empetrum nigrum* than is usual for C30.

Table 140 Stand (AW7085) illustrating the Engelmann spruce-subalpine fir/Labrador tea, crowberry (C30) v.t. of the BY4 Ecosite.

TREE LAYER	
Picea engelmannii	15
Pinus albicaulis	01
Pinus contorta	10
TALL SHRUB LAYER	
Pinus contorta	02
Picea engelmannii	01
SHRUB LAYER	
Abies lasiocarpa	01
Juniperus communis	01
Ledum groenlandicum	08
Pinus contorta	02
Picea engelmannii	02
Shepherdia canadensis	.5
HERB-DWARF SHRUB LAYER	
Carex concinnoides	01
Elymus innovatus	04
Empetrum nigrum	01
Linnaea borealis	02
Phyllodoce glanduliflora	.5
Salix vestita	.5
Solidago decumbens	.5
Vaccinium scoparium	40
Vaccinium vitis-idaea	03
Equisetum scirpoides	.5
BRYOID LAYER	
Dicranum spp.	07
Cladonia mitis	02
Cladonia spp.	26
Hylocomium splendens	25
Peltigera aphthosa	01
Peltigera canina	01
Polytrichum juniperinum	03

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

The BY4 Ecosite is the least extensive of the Bryant Ecosites and is not predominant in either the Front Ranges as is BY2 or Main Ranges as is BY1. Genetic material and landform surface expression differentiate BY4 from BY1 and BY2 as outlined in Table 134. The Panorama Ridge 6 (PR6) Ecosite has landforms and genetic material similar to BY4 but is differentiated because it is dominated by lodgepole pine forest occurring on soils with luvisolic tendencies. The Baker Creek 6 (BK6) Ecosite has similar landforms, genetic material, and vegetation on its upland (dry) segment but is differentiated from BY4 because it also includes about 30% wet depressions.

BZ - BRAZEAU ECOSECTION

The Brazeau (BZ) Ecosection is characterized by hummocky terrain comprised of noncalcareous, medium textured residuum (Residuum A) or calcareous, medium textured residuum (Residuum B) that occurs on valley walls and floors in the Lower Subalpine portion of the Subalpine Ecoregion. The BZ Ecosection is of very limited extent and occurs in areas underlain by failed Mesozoic strata in the Front Ranges. It is mapped only near Maligne and Brazeau Lakes in Jasper, and is dominated by lithic phases of Brunisolic soils associated with either Engelmann spruce-subalpine fir or lodgepole pine forests.

Table 141 General features of the Brazeau (BZ) Ecosites.

Ecosite	Landform	Soils	Vegetation
BZ1	Residuum A,B; hummocky	lithic phases of Brunisolic	Engelmann spruce-subalpine fir forest
BZ2	Residuum A,B; hummocky	lithic phases of Brunisolic	lodgepole pine forest

Table 142 Pedon (Alberta 1977 No. 118) description of an Eluviated Dystric Brunisol of the BZ1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: BZ1.

LOCATION: MILITARY GRID REF. 11 UMJ 5650 4360; NTS MAP AREA 83C 12W.

CLIMATE: 1720 METERS ABOVE MEAN SEA LEVEL. STATION AT MALIGNE LAKE HAS GOOD RELEVANCE TO THE SOIL SITE.

VEGETATION: VPN=JC7103*VTH=C29W.

SOIL SITE: PARENT MATERIAL 1: COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.3), EOLIAN, SHALE; PARENT MATERIAL 2: FRACTURED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), RESIDUAL, SHALE; DEPTH TO BEDROCK IS 0.3 M; LANDFORM CLASSIFICATION: UNDIFFERENTIATED, HUMMOCKY; SLOPE: 3% COMPLEX SLOPE OF CLASS 3 (2-5%), FACING SOUTHWEST, SITE AT UPPER SLOPE POSITION, MODERATELY MOUNDED MICROTOPOGRAPHY,; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF; NONSTONY; NONROCKY.

SPECIAL NOTES: SSN=DA7148*APN=010-106*PCF=1SH(3)4SH(4)6SH(5)*YELLOW MYCELLIAIN LF*LFH=EV/RH*

LF: 3 TO 0 CM, RANGE 2 TO 4 CM; HORIZON MOIST; MATRIX MOIST ; ABUNDANT, FINE AND MEDIUM AND COARSE, HORIZONTAL ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 5 CM, RANGE 3 TO 7 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/2; SILT LOAM; WEAK, FINE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, FINE AND MEDIUM, HORIZONTAL, INPED ROOTS; FEW, VERY FINE AND FINE, RANDOM, DISCONTINUOUS, VESICULAR PORES; WAVY, ABRUPT HORIZON BOUNDARY.

BM: 5 TO 12 CM, RANGE 4 TO 10 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/8; SILT LOAM; WEAK, FINE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM, HORIZONTAL, INPED ROOTS; FEW, VERY FINE AND FINE, RANDOM, DISCONTINUOUS, VESICULAR PORES; SHALY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY; STRONGLY ACID 5.1-5.5 FIELD PH.

2BC1: 12 TO 17 CM, RANGE 0 TO 9 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/4; SILT LOAM; WEAK, FINE, PLATY STRUCTURE; WEAK TO MODERATE, FINE TO MEDIUM, ANGULAR BLOCKY SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE AND MEDIUM, OBLIQUE, INPED ROOTS; FEW, VERY FINE AND FINE, RANDOM, DISCONTINUOUS, VESICULAR PORES; SHALY COARSE FRAGMENTS; BROKEN, DIFFUSE HORIZON BOUNDARY.

2BC2: 17 TO 24 CM, RANGE 0 TO 15 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/3; LOAM; STRUCTURELESS STRUCTURE; LOOSE CONSISTENCE; VERY FEW, VERY FINE AND FINE, OBLIQUE ROOTS; SHALY COARSE FRAGMENTS; BROKEN, DIFFUSE HORIZON BOUNDARY.

R: 24 CM

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)
LF	4.0	47.20
AE	3.9	0.16
BM	5.0	0.21
2BC1	5.0	
2BC2	6.0	
R		

CHEMICAL DATA (SURVEY)

	EXTRACT IRON (%)		EXTRACT ALUMINUM (%)	
HORIZON	1	2	1	2
LF				
AE				
BM	0.1		0.2	
2BC1				
2BC2				
R				

PHYSICAL DATA (SURVEY)

	% PASSING				PARTICLE SIZE ANALYSIS						% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE					1	1	1	2	14	19		72	9	0
BM					1	2	2	2	12	19		75	6	0
2BC1					3	6	6	6	9	30		60	10	1
2BC2		99	64	27	20	12	16	11	9	8	56		35	9	0
R														

PHYSICAL DATA

	ENGINEERING						
HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AE								
BM								
2BC1								
2BC2	27.0	30.0					10	2
R								

Two Ecosties (BZ1, BZ2) have been separated within the BZ Ecosection on vegetational differences as outlined in Table 141.

BZ1 - BRAZEAU 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, BZ1, occurs on hummocky slopes comprised of noncalcareous, medium textured residuum (Residuum A) or calcareous, medium textured residuum (Residuum B). It is dominated by lithic phases of well drained Eluviated Dystric Brunisols and Eluviated Eutric Brunisols associated with the Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t.s.

Two tracts of BZ1 are mapped, both in Jasper. One straddles a tributary of the Brazeau River near the outlet of Brazeau Lake and the other occurs at the northwest end of Maligne Lake. Both tracts are partially responsible for the damming that causes the lakes.

Geomorphology

The BZ1 Ecosite occurs on hummocky terrain comprised of noncalcareous, medium textured residuum (Residuum A) or calcareous, medium textured residuum (Residuum B). The Maligne Lake tract is dominated by noncalcareous, medium textured residuum; the Brazeau Lake tract by calcareous, medium textured residuum. These landforms consist of failed Mesozoic shale bedrock that now occupy valley floor positions. Bedding within the shaly parent material is present at depth. Shale content increases with depth to a lithic contact. Discontinuous veneers of altered, medium textured eolian material (Eolian material B) occur on BZ1. Slopes commonly range from 5 to 15%.

Soils

The BZ1 Ecosite is dominated by well drained lithic phases of Eluviated Dystric Brunisols and Eluviated Eutric Brunisols. These soils are developed on weathered Mesozoic shales and, because they reflect the nature of the bedrock, are variable in their chemical characteristics. Eluviated Dystric Brunisols are associated with noncalcareous, medium textured residuum (Residuum A) and Eluviated Eutric Brunisols with calcareous, medium textured residuum (Residuum B). Shale fragment content and size increases with depth to a lithic contact. Orientation of shaly coarse fragments in the weathering zone conforms to the original bedding planes of the underlying parent rock. A pedon described for BZ2 in Table 142 and shown in Color Plate 13 illustrates a lithic phase Eluviated Dystric Brunisol of the BZ1 Ecosite.

Vegetation

The BZ1 Ecosite is dominated by the mesic Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t.s. The C30 v.t. occurs on the Maligne Lake BZ1 tract. The C31 v.t. dominates the Brazeau Lake BZ1 tract. A stand illustrating C31 of the BZ1 Ecosite is described in Table 143. The C30 and C31 v.t.s are thought to be fire remnants and are the main criteria for separating BZ1 from the lodgepole pine dominated BZ2.

Table 143 Stand (CC6068) illustrating the Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t. of the BZ1 Ecosite.

TREE LAYER	
Picea engelmannii	70
Pinus contorta	10
TALL SHRUB LAYER	
Picea engelmannii	03
SHRUB LAYER	
Juniperus communis	.5
Ledum groenlandicum	04
Shepherdia canadensis	.5
HERB-DWARF SHRUB LAYER	
Arnica cordifolia	03
Elymus innovatus	06
Linnaea borealis	10
Pyrola secunda	02
Vaccinium vitis-idaea	08

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

The BZ1 Ecosite is the least extensive of the two Brazeau Ecosites and is of very limited extent overall. Vegetational differences are the main criteria for separating BZ1 from BZ2 as outlined in in Table 141. In terms of physiographic position, landform surface expression, soils and vegetation, BZ1 most closely resembles the Ishbel 3 (IB3) Ecosite. The latter is distinguished because it is a landslide deposit with a heterogeneous mixture of soil and rock with many stones and boulders occurring in the weathering zone and on the surface. The BZ1 Ecosite also occurs on failed slopes but is differentiated by its uniform orientation of predominantly shaly coarse fragments in the weathering zone. It should be noted that shales are easily eroded by streams as evidenced by the shale escarpments below the outlet of Brazeau Lake.

BZ2 - BRAZEAU 2 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, BZ2, occurs on hummocky terrain comprised of noncalcareous, medium textured residuum (Residuum A) or calcareous, medium textured residuum (Residuum B). It is dominated by lithic phases of well drained Eluviated Dystric Brunisols and Eluviated Eutric Brunisols associated with the lodgepole pine/buffaloberry/grouseberry (C18) and lodgepole pine/Labrador tea (C29) v.t.s.

Four tracts of BZ2 are mapped, three occurring near Maligne Lake, and one near the outlet of Brazeau Lake. The two tracts of BZ2 at the outlet of Maligne Lake are largely responsible for the lake's existence.

Geomorphology

The BZ2 Ecosite occurs on hummocky terrain comprised of noncalcareous, medium textured residuum (Residuum A) or calcareous, medium textured residuum (Residuum B). The Maligne Lake tracts are dominated by noncalcareous, medium textured residuum, the Brazeau Lake tract by calcareous, medium textured residuum. These landforms consist of failed Mesozoic bedrock that now occupies valley wall and floor positions. Bedding is present within the shaly parent material at depth. Landslide deposits are often mapped adjacent to BZ2. Slopes are primarily complex and range from 15 to 45%. Shales on BZ2 are easily eroded by stream abrasion. Discontinuous surficial veneers of altered, medium textured eolian material (Eolian material B) occur on BZ2.

Soils

The BZ2 Ecosite is dominated by well drained lithic phases of Eluviated Dystric Brunisols and Eluviated Eutric Brunisols. These soils are developed on weathered shales and their chemical characteristics reflect the nature of the bedrock. The Eluviated Dystric Brunisols are associatd with noncalcareous, medium textured residuum (Residuum A), the Eluviated Eutric Brunisols with calcareous, medium textured residuum (Residuum B). Shale fragment content and size increases with depth to a lithic contact. Orientation of shaly coarse fragments in the weathering zone conforms to the original bedding planes of the underlying parent rock. Minor amounts of lithic phase Orthic Dystric Brunisols and Orthic Eutric Brunisols occur on steeper slopes. A pedon illustrating the lithic phase Eluviated Dystric Brunisol is described in Table 142 and shown in Color Plate 13. This pedon was sampled on a BZ2 tract adjacent to the outlet of Maligne Lake in Jasper.

Vegetation

The BZ2 Ecosite is dominated by the mesic lodgepole pine/buffaloberry/grouseberry (C18) and lodgepole pine/Labrador tea (C29) v.t.s. The C18 v.t. is primarily found on steeper tracts of BZ2. The C18 v.t. on the tract between Opal Hills and Maligne Lake is transitional to the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. near the Upper Subalpine boundary. The C29 v.t. is primarily found on more gentle slopes. The vegetation plot description in Table 144 and shown in Plate 97 illustrates the C29 v.t. on BZ2 and represents the vegetation at the pedon sample site described above in Table 142.

Table 144 Stand (JC7103) illustrating the lodgepole pine/Labrador tea (C29) v.t. of the BZ2 Ecosite.

TREE LAYER	
Picea engelmannii	03
Pinus contorta	32
TALL SHRUB LAYER	
Pinus contorta	.5
SHRUB LAYER	
Juniperus communis	02
Ledum groenlandicum	18
Picea engelmannii	01
Salix spp.	04
HERB-DWARF SHRUB LAYER	
Cornus canadensis	03
Elymus innovatus	01
Epilobium angustifolium	.5
Linnaea borealis	03
Vaccinium caespitosum	04
Vaccinium scoparium	01
Vaccinium vitis-idaea	02
Equisetum scirpoides	11
BRYOID LAYER	
Cetraria ericetorum	.5
Cladonia mitis	.5
Cladonia carneola	.5
Cladonia cenotea	.5
Cladonia ecmocyna	.5
Cladonia gonecha	01
Cladonia gracilis	.5
Dicranum fuscescens	03
Hylocomium splendens	08
Peltigera aphthosa	04
Pleurozium schreberi	80
Polytrichum commune	01
Polytrichum juniperinum	01
Ptilium crista-castrensis	01
Stereocaulon tomentosum	.5
Barbilophozia lycopodioides	01
EPIPHYTES	
Letharia vulpina	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The BZ2 Ecosite is very limited in areal extent and occurs near Maligne and Brazeau Lakes in Jasper. It most closely resembles the Ishbel 1 (IB1) Ecosite in terms of physiographic position, landform surface expression, soils and vegetation. The two Ecosites are often mapped adjacent to each other. The IB1 Ecosite is distinguished because it occurs on landslide deposits with a heterogeneous mixture of soil and rock with many stones and boulders occurring in the weathering zone and on the surface. The BZ2 Ecosite also occurs on failed slopes but is differentiated by its uniform orientation of predominantly shaly coarse fragments in the weathering zone.

CA - CAVELL ECOSECTION

The Cavell Ecosection encompasses morainal landforms comprised of noncalcareous, medium textured till (Till B) in the Lower Subalpine portion of the Subalpine Ecoregion in Banff and Jasper. The CA Ecosection occurs most extensively in the Main Ranges in association with Precambrian Miette Group slates and shales. It also occurs in the Front Ranges in association with noncalcareous Mesozoic strata, and is found primarily on valley walls and floors including benchlands in broad valleys.

The dominant soils, Dystric Brunisols, are moderately developed and reflect the noncalcareous, medium textured parent material. Two groups of coniferous forest and a dry > wet pattern differentiate the three Cavell (CA) Ecosites (Table 145). Fig. 35 shows, schematically, the physiographic positions of the Cavell Ecosites and their relationship to other Ecosites.

CA1 - CAVELL 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, CA1, occurs on hummocky or ridged morainal landforms consisting of noncalcareous, medium textured till (Till B). Landform surface expression may be of depositional orgin or controlled by underlying bedrock. Its complex topography forms a compound landscape comprised of about 70% dry (well to moderately well drained, mesic) upland segments and 30% wet (poorly to very poorly drained, hygric to hydric) depressions between ridges and hummocks. Upland segments are characterized by a soil pattern in which Eluviated Dystric Brunisols are dominant, Orthic Dystric Brunisols subdominant. Vegetation of upland segments is dominated by the Engelmann spruce-subalpine fir/false azalea (C14), Engelmann spruce-subalpine fir/feathermoss (C13), and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s. The C14 v.t. occurs most often. Wet depressional segments contain a variety of pedogenically related wet soils best represented by the Orthic Gleysol, Rego Gleysol, Gleyed Ferro-Humic Podzol, and Terric Mesisol Subgroups. Vegetation of depressions is dominated by the spruce/Labrador tea/brown moss (O11), Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14), dwarf birch-shrubby cinquefoil-willow/brown moss (S1), and dwarf birch-shrubby cinquefoil/needlerush (S3) v.t.s. O11 and O14 are most abundant.

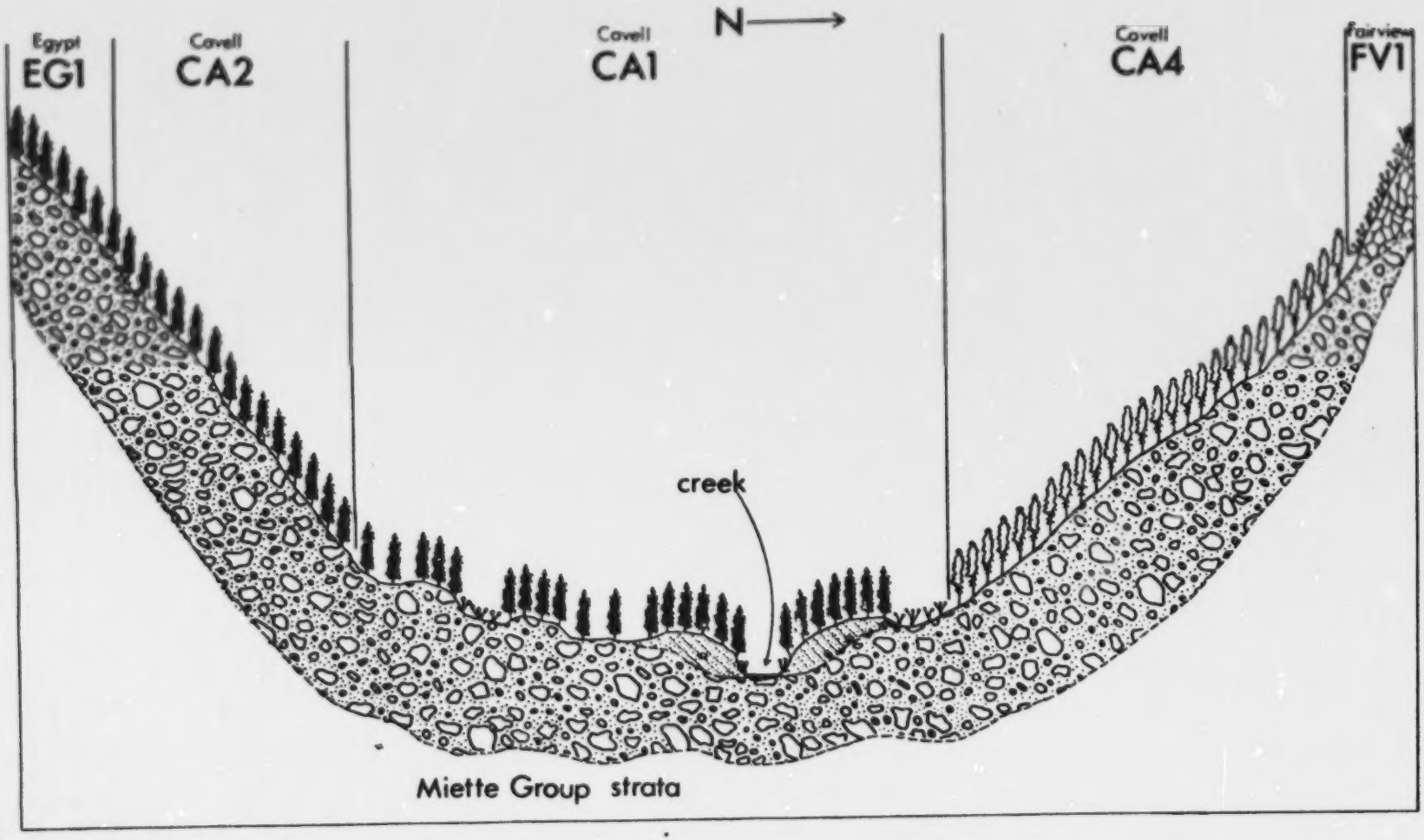
Geomorphology

The CA1 Ecosite is typified by morainal landforms consisting of noncalcareous, medium textured till (Till B). In a few areas, e.g. upper Mistaya River valley near Peyto Lake in Banff and Athabasca Pass in Jasper, CA1 tracts include morainal landforms consisting of noncalcareous, coarse textured till (Till A). A medium textured variant of noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A), derived from slates and shales, dominates a few CA1 tracts of valley floors and lower slopes, e.g. upper Miette River valley in Jasper. Included in this glacial material are the abandoned side glacial stream channels described by Rutter (1972) that occur near Eisenhower Junction in Banff. Surface veneers

Table 145 General features of the Cavell (CA) Ecosites.

Ecosite	Landform	Soils	Vegetation
CA1	Till B; blanket, hummocky, ridged	Dry[%]: Dystric Brunisol Wet[%]: Gleysolic, gleyed Podzolic, Organic	Dry[%]: Engelmann spruce-subalpine fir forest Wet[%]: Wet spruce open forest, wet Engelmann spruce-subalpine fir open forest, wet shrubby meadow, birch fen
CA2	Till B; blanket	Dystric Brunisol	Engelmann spruce-subalpine fir forest
CA4	Till B; blanket	Dystric Brunisol	lodgepole pine forest

Figure 35 Schematic cross-section showing the relationship of the Cavell (CA) Ecosites to other Ecosites.



of altered, medium textured eolian material (Eolian material B) occur extensively on CA1 tracts of western Banff and southwestern Jasper and sporadically elsewhere. Redeposited Eolian material B plus eroded till as thin veneers of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) occurs in channeled depressions. Mineral soil materials of wet depressions are usually thinly mantled by peat derived primarily from sedges and brown mosses (e.g. *Tomenthypnum nitens* and *Aulacomnium palustre*). This fen peat, rarely exceeding 1.2 m in thickness, is mainly moderately decomposed but fibric and humic layers also occur. Occasionally, wood fragments may be found. Where the peat is >40 cm thick, the landform is classified as horizontal fen (C.S.S.C. 1978b), recognizing that in some localities fen vegetation has been succeeded by open forest.

Topographically, CA1 displays irregular hummocky or ridged slopes on valley floors including benchlands and on lower valley wall slopes. Occasionally, CA1 occurs on valley shoulders. Slopes commonly range from 5 to 45%. Hummocky and ridged surfaces reflect underlying bedrock surfaces, glacial deposition, or postglacial slope failure. Failed till slopes on CA1 tracts are usually seepage-induced rotational slumps, but remnant rock glacier landforms also occur. Slope failure status may be active or inactive. Morainal veneers occur infrequently except on CA1X (e.g. Miette River valley near Rink Brook in Jasper) where they dominate. Bedrock outcrops occur occasionally.

Soils

Soils of the CA1 Ecosite are distributed in a pattern governed by drainage conditions. Soils of the well to moderately well drained upland segments are distributed in a secondary pattern reflecting degree of eluvial (Ae) horison development. Eluviated Dystric Brunisols are dominant; Orthic Dystric Brunisols subdominant. These soils have B horizons that range from moderately developed Bm horizons at the till surface to the comparatively advanced B, and Bf horizons associated with altered, medium textured eolian material (Eolian material B) veneers. Genetically related Orthic Humo-Ferric Podzols, with podzolic Bf horizons above the parent material disconformity, are important accessory soils. These are most abundant on CA1 tracts with extensive Eolian material B veneers. Soils with Bhf horizons occur in minor amounts.

Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly developed in the absence of Eolian material B. In some localities, recent surface disturbances such as windthrow of trees, sheet erosion, and soil creep have inhibited or destroyed Ae horizon development. Many CA1 upland soils display, in their lower sola and upper C horizons, clay films that are thought to be formed by pressure (e.g. freeze-thaw). Lithic soil phases are associated with morainal veneers and dominate on CA1X tracts. The pedons described in Tables 148 and 150 for the CA2 and CA4 Ecosites illustrate the upland soils of CA1.

A variety of pedogenically related soils occur on the poorly to very poorly drained depressional segments of CA1. These are best represented by the Orthic Gleysol, Rego Gleysol, Gleyed Ferro-Humic Podzol, and Terric Mesisol Subgroups. The amount of gleying, reflecting degree of movement and aeration of seepage waters, is variable. The accessory soils, Gleyed Dystric Brunisols, occur on sites where gleying is weakly expressed. Prolonged periods of saturation give strongly gleyed soils with little or no pedogenic horizonation (Rego Gleysols). In some localities, recent or continuing fluvial activity has inhibited horizon development and organic matter accumulation. Orthic Gleysols and Gleyed Ferro-Humic Podzols occur in localities with shorter periods of saturation. Additionally, the presence of eolian or fluviolacustrine veneers promotes the development of iron, aluminum, and humus enriched B and podzolic B horizons (usually Bhf and podzolic Bhf). Favorable moisture, nutrient, and vegetation conditions have resulted in the accumulation of varying thicknesses of fen peat on most depressional soils. Terric Mesisols occur where the peat is >40 cm thick. Other Organic soils with subdominant humic or fibric layers, Gleyed Eluviated Dystric Brunisols, and Humic Gleysols occur occasionally.

A pedon illustrating gleyed Podzolic soils of CA1 wet segments is described in Table 146. Plate 98 shows the sample site. This pedon has a podzolic Bh horizon with high pyrophosphate extractable iron and aluminum. It has developed in Eolian material B immediately above the till. The presence of Bhf and podzolic Bhf horizons tend to be more common in this setting. The low amount of calcium carbonate in this profile is attributed to groundwater discharge.

Vegetation

Vegetation of the CA1 Ecosite is distributed in a pattern governed by drainage conditions. The Engelmann spruce-subalpine fir/false azalea (C14), Engelmann spruce-subalpine fir/feathermoss (C13), and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s dominate the well to moderately well drained upland segments. The C14 v.t. is the most abundant v.t. but on some tracts C13 or C21 dominate upland segments. The C13 v.t. occurs more often at low elevations on gentle slopes and in central and eastern areas of both parks. In northern Jasper and along

Table 146 Pedon (Alberta 1977 No. 143) description illustrating gleyed Podzolic soils of wet segments of the CA1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC HUMIC PODZOL. SOIL MAP UNIT: NOTATION: CA1.

LOCATION: MILITARY GRID REF. 11 UNG 7000 8000; NTS MAP AREA 82O SW.

CLIMATE: 1670 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), EOLIAN, UNDIFFERENTIATED OR UNDETERMINED; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), MORAINAL (TILL); LANDFORM CLASSIFICATION: MORAINAL AND UNCONSOLIDATED; SLOPE: 25% COMPLEX SLOPE OF CLASS 6 (16-30%), FACING NORTHEAST, SITE AT UPPER SLOPE POSITION, 100 M LONG; SOIL MOISTURE AND DRAINAGE: POORLY DRAINED, SEEPAGE PRESENT; MODERATELY STONY.

SPECIAL NOTES: SSN=DC7056*APH=783-876*RLU=15*SSC=MXR*PCF=3GR,1CB(3-4)*LFM=MXR*

OH: 13 TO 0 CM, RANGE 12 TO 17 CM; MATRIX MOIST 7.5YR 2.5/0; ABUNDANT, FINE AND MEDIUM ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

BHGJ: 0 TO 15 CM, RANGE 12 TO 18 CM; MATRIX MOIST 5YR 4/4, MATRIX MOIST 5YR 5/6; SILT LOAM; FEW, COARSE, DISTINCT, 2.5YR 4/6 MOTTLES; WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE ROOTS; MANY, FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

2BG: 15 TO 40 CM, RANGE 23 TO 27 CM; MATRIX MOIST 2.5Y 6/4; LOAM; COMMON, FINE, PROMINENT, 7.5YR 5/6 MOTTLES; MODERATE, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, FINE ROOTS; COMMON, VERY FINE PORES; COMMON, THIN CLAY FILMS ; GRAVELLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2BCG: 40 TO 105 CM; MATRIX MOIST 2.5Y 6/4; LOAM; COMMON, MEDIUM, PROMINENT, 7.5YR 5/6 MOTTLES; WEAK, COARSE, SUBANGULAR BLOCKY STRUCTURE; MASSIVE SECONDARY STRUCTURE; FRIABLE CONSISTENCE; FEW, FINE PORES; COMMON, THIN CLAY FILMS ; GRAVELLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PEPH. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
OH	6.5	45.90	1.4						
BHGJ	6.4	7.20		44.8		38.1	7.6	0.1	0.2
2BG	6.4	0.40		5.6		5.5	1.5	<.1	0.1
2BCG	6.9		1.7						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
OH				
BHGJ	0.2		0.2	
2BG	0.1		<.1	
2BCG	0.1		0.1	

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS % PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-50- CU SILT	50-2U SILT	2U CLAY	0.2U CLAY
OH														
BHGJ										19		69	12	3
2BG										35		45	20	5
2BCG	99	85	76	61						41		44	15	4

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
OH								
BHGJ								
2BG								
2BCG	12.0	20.0					A6	SM

the Continental Divide, C21 sometimes replaces C14. Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) occur in minor amounts in central to eastern areas. In areas where fire has been a factor, lodgepole pine forest, best represented by the moist lodgepole pine/false azalea/grouseberry (C20) and lodgepole pine/Labrador tea (C29) v.t.s, is important. Lodgepole pine/buffaloberry/grouseberry (C18) also occurs occasionally. Modification of these spruce and pine v.t.s. by recent fires has occurred in some areas which are mapped as CA1B, e.g. upper Mistaya River valley in Banff. Occasionally, modification by avalanching occurs.

Vegetation of depressional segments, dominated by the spruce/Labrador tea/brown moss (O11), Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14), dwarf birch-shrubby cinquefoil-willow/brown moss (S1), and dwarf birch-shrubby cinquefoil/needlerush (S3) v.t.s, reflects poor drainage. The O11 and O14 v.t.s. are most abundant but S1 and S3 dominate some of the more gently sloping benches and depressions within CA1 tracts. Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6) is an accessory v.t. and occurs on gently sloping localities with fluvial and organic deposits. Engelmann spruce-subalpine fir/valerian-fleabane (O9) and water sedge-beaked sedge (H11) occur in minor amounts. A plot illustrating S1 on

wet depressional segments of CA1 is described in Table 147. This plot is located on the same tract as the pedon sample site described above (Table 146).

Table 147 Stand (AW5017) illustrating the dwarf birch-shrubby cinquefoil-willow/brown moss (S1) v.t. of wet segments of the CA1 Ecosite.

TALL SHRUB LAYER	
Picea engelmannii	04
SHRUB LAYER	
Betula glandulosa	20
Ledum groenlandicum	15
Picea engelmannii	04
Potentilla fruticosa	25
Salix glauca	05
HERB-DWARF SHRUB LAYER	
Arctostaphylos rubra	35
Carex aquatilis	35
Carex vaginata	06
Castilleja spp.	.5
Linnaea borealis	02
Mitella nuda	.5
Oxycoccus microcarpus	03
Pedicularis groenlandica	.5
Polygonum viviparum	.5
Rubus acaulis	01
Senecio indecorus	.5
Zygadenus elegans	.5
Equisetum arvense	.5
Equisetum spp.	.5
BRYOID LAYER	
Campylium stellatum	.5
Sphagnum warnstorfii	30
Tomenthypnum nitens	20

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

The CA1 Ecosite encompasses a compound landscape pattern consisting of well drained upland segments similar to the Cavell 2 (CA2) Ecosite and poorly to very poorly drained depressional segments similar to the Consolation Valley 1 (CV1) and, occasionally, Hector 1 (HC1) or Hector 4 (HC4) Ecosites. The proportion of wet depressions on CA1 commonly ranges from 20 to 40%. Map presentation of CA1 tracts at scales larger than 1:50,000 is invalid because at these scales the upland and wet segments become mappable as separate Ecosites. In terms of physiographic position, landform surface expression, and vegetation cover, CA1 resembles the Baker Creek 6 (BK6) Ecosite. However, BK6 is distinguished because it occurs on glacial landforms consisting of calcareous, medium textured till (Till C) and calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). Upland segments of BK6 are dominated by Eutric Brunisols. The CA1 Ecosite is the only Cavell Ecosite with a dry > wet pattern (Table 145). The Egypt 3 (EG3) Ecosite is the Upper Subalpine counterpart of CA1.

CA2 - CAVELL 2 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, CA2, occurs on morainal blankets consisting of noncalcareous, medium textured till (Till B) overlying inclined bedrock on valley walls. These well drained soils normally occur in a pattern reflecting the degree of eluvial (Ae) horizon development. Eluviated Dystric Brunisols are dominant and Orthic Dystric Brunisols subdominant. Vegetation cover is dominated by the Engelmann spruce-subalpine fir/false azalea (C14), Engelmann spruce-subalpine fir/feathermoss (C13), and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s. C14 is most abundant.

Geomorphology

The CA2 Ecosite is typified by morainal blankets overlying inclined bedrock. The moraines consist of noncalcareous, medium textured till (Till B). Surface veneers of altered, medium textured eolian material (Eolian material B) occur extensively on CA2 tracts of western Banff and southwestern Jasper and sporadically elsewhere. Colluvium derived from till and fractured bedrock is found occasionally on the steepest portions of the landscape. A medium textured variant of noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A), derived from slates and shales, occurs occasionally on valley floors and lower slopes.

Topographically, CA2 displays long, linear slopes consisting of till blankets mantling the inclined bedrock that forms valley walls. Slopes commonly range from 15 to 70%. Gullied slopes occur, but much less frequently than on the Bryant 1 and 2 (BY1, BY2), and Moraine Lake 1 (ML1) Ecosites. Colluvial blankets and veneers occur locally on the steepest terrain, particularly below bedrock escarpments. Tracts of CA2 situated along valley bottoms and shoulders, at valley confluences, in cirque basins and cols, and on failed slopes often display morainal landforms with irregular surfaces and complex topography (5-45% slopes). These landforms include morainal blankets and veneers overlying ridged and hummocky bedrock and the relatively deep till of hummocky moraines. Morainal veneers also occur on linear, inclined slopes and are dominant on tracts mapped as CA2X. Bedrock outcrops occur occasionally but are particularly common on CA2+R tracts.

Soils

The CA2 Ecosite is characterized by a pattern of soils that reflects the degree of eluvial (Ae) horizon development. Eluviated Dys-

Table 148 Pedon (Alberta 1979 No. 78) description of an Eluviated Dystric Brunisol of the CA2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: CA2.

LOCATION: MILITARY GRID REF. 11 UMJ 2710 4790; NTS MAP AREA 83D 16*.

CLIMATE: 1940 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS MODERATE RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 2 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JE9100*VTN=C14*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<10% CLAY) AND STRATIFIED (MINERAL), MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), MORAINAL (TILL), SLATE AND QUARTZITE; LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 35% SIMPLE SLOPE OF CLASS 7 (31-45%), FACING NORTH, SITE AT MIDDLE POSITION, SLIGHTLY ROUNDED MICROTOPOGRAPHY,500 M LONG; SOIL MOISTURE AND DRAINAGE: MODERATELY WELL DRAINED, SLOWLY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; SLIGHTLY STONY; NONROCKY.

SPECIAL NOTES: SSN=BW9131*APN=A23015-67*RLU=15*PCF=15L(2)16R,25L,1CB,1FL(3)35L,2GR,1CB,1FL,1ST(4)25L,1GR,1CB,1FL,1ST(5)3GR,35L,2CB, 2FL,1ST(6,9)2GR,25L,1CB,1FL,1ST(7)4GR,35L,3CB,2FL,1ST(8)*C1,C2,C3 ARE INTERLAYED*SSC*ST*AE+BM IN EOLIAN-TILL MIXTURE* OCCASIONA L MOTTLE IN LOWER HORIZONS*DATE=SEPT.12,1979*

LF: 7 TO 0 CM, RANGE 5 TO 13 CM; MATRIX MOIST 10YR 2/2; ABUNDANT, MICRO AND VERY FINE AND FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 5 CM, RANGE 1 TO 9 CM; MATRIX MOIST 10YR 6/3, MATRIX MOIST 10YR 7/3; SILT LOAM; WEAK, COARSE, PLATY STRUCTURE; VERY WEAK, VERY FINE, PLATY SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE ROOTS; FEW, MICRO PORES; WAVY, ABRUPT HORIZON BOUNDARY.

BM: 5 TO 23 CM, RANGE 16 TO 20 CM; MATRIX MOIST 7.5YR 5/6, MATRIX MOIST 7.5YR 3/4; LOAM; VERY WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; WEAK, VERY FINE TO FINE, GRANULAR SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO AND FINE ROOTS; MANY, MICRO AND VERY FINE PORES; 20% GRAVELLY AND SLATY AND COBBLY AND FLAGGY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BC: 23 TO 43 CM, RANGE 17 TO 21 CM; MATRIX MOIST 10YR 5/4, MATRIX MOIST 10YR 4/4; LOAM; WEAK TO MODERATE, COARSE, PLATY STRUCTURE; WEAK TO MODERATE, FINE, SUBANGULAR BLOCKY SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE ROOTS; COMMON, MICRO PORES; FEW, VERY THIN CLAY FILMS ON PED FACES-UNSPECIFIED; 40% GRAVELLY AND SLATY AND COBBLY AND FLAGGY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY; STRONGLY ACID 5.1-5.5 FIELD PH.

C1: 43 TO 59 CM, RANGE 14 TO 20 CM; MATRIX MOIST 2.5Y 5/4; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; WEAK, MEDIUM TO COARSE, SUBANGULAR BLOCKY SECONDARY STRUCTURE PSEUDO; FIRM CONSISTENCE; FEW, MICRO AND VERY FINE ROOTS; COMMON, MICRO AND VERY FINE PORES; COMMON, VERY THIN CLAY FILMS ON PED FACES-UNSPECIFIED; 20% GRAVELLY AND SLATY AND COBBLY AND FLAGGY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

C2: 59 TO 87 CM, RANGE 24 TO 30 CM; MATRIX MOIST 10YR 5/4, MATRIX MOIST 2.5Y 5/2; SANDY LOAM; WEAK, MEDIUM TO COARSE, SUBANGULAR BLOCKY STRUCTURE PSEUDO; FRIABLE CONSISTENCE; VERY FEW, MICRO AND VERY FINE ROOTS; MANY, MICRO AND VERY FINE PORES; VERY THIN CLAY FILMS IN MANY VOIDS/CHANNELS AND ON SOME VERTICAL AND HORIZONTAL PED FACES; 50% GRAVELLY AND SLATY AND COBBLY AND FLAGGY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY; MEDIUM ACID 5.6-6.0 FIELD PH.

C3: 87 TO 106 CM, RANGE 15 TO 25 CM; MATRIX MOIST 2.5Y 5/4; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; WEAK TO MODERATE, COARSE, SUBANGULAR BLOCKY SECONDARY STRUCTURE PSEUDO; FRIABLE CONSISTENCE; VERY FEW, MICRO ROOTS; COMMON, MICRO AND VERY FINE PORES; MANY, THIN CLAY FILMS IN MANY VOIDS/CHANNELS AND ON SOME VERTICAL AND HORIZONTAL PED FACES; 30% GRAVELLY AND SLATY AND COBBLY AND FLAGGY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

C4: 106 TO 111 CM, RANGE 8 TO 11 CM; MATRIX MOIST 10YR 5/3; COARSE SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, MICRO ROOTS; 70% GRAVELLY AND SLATY AND COBBLY AND FLAGGY AND STONY (BOULDERY) COARSE FRAGMENTS; BROKEN,

C5: 111 TO 140 CM; MATRIX MOIST 10YR 5/3.5; SANDY LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE PSEUDO; STRUCTURELESS SECONDARY STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, MICRO ROOTS; MANY, MICRO AND VERY FINE PORES; MANY, THIN CLAY FILMS IN MANY VOIDS/CHANNELS AND ON SOME VERTICAL AND HORIZONTAL PED FACES; 50% GRAVELLY AND SLATY AND COBBLY AND FLAGGY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	CRB C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) FERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	3.8	32.40							
AE	4.4	2.90		13.7		2.4	0.5	0.1	0.2
BM	4.8	2.60		19.2		3.2	0.3	-.1	0.2
BC	5.2			8.5		2.4	0.4	-.1	0.2
C1	5.8			3.5		2.6	0.7	-.1	0.1
C2	5.6			2.1		1.9	0.6	-.1	0.1
C3	5.8			3.9		3.4	1.1	0.1	0.1
C4	6.0		0.2	1.6		2.2	0.7	-.1	0.1
C5	6.0		1.1						

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AE								
BM								
BC								
C1	14.0	18.0					5%	18
C2								
C3								
C4								
C5	11.0	17.0					12	18

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	0.4		0.1	
BC				
C1				
C2				
C3				
C4				
C5				

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS X PASSING 3" SIEVE	.75" SIEVE	#5.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 78-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF															
AE					1	2	4	6	13	26		66	8		
BM					7	10	10	9	6	42		45	13		
BC					9	11	12	12	6	50		37	13		
C1		99	96	91	2	5	7	12	9	35		53	12		2.10
C2					6	12	15	17	9	61		31	8		2.20
C3					2	4	5	9	8	28		54	18		1.90
C4					16	21	17	12	5	73		21	6		
C5		99	88	52	40	9	12	14	15	7	57	36	9		2.00

tric Brunisols are dominant and Orthic Dystric Brunisols subdominant. These well to moderately well drained soils have B horizons that range from moderately developed Bm horizons, at the till surface, to the strongly developed Bm and Bf horizons associated with altered, medium textured eolian (Eolian material B) veneers. Genetically related Orthic Humo-Ferric Podzols, with Bf horizons in the eolian material above the parent material disconformity, are important accessory soils. Soils with Bhf horizons occur in minor amounts. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly developed in the absence of Eolian material B. In some localities, recent surface disturbances such as windthrow of trees, avalanching, sheet erosion, and soil creep have inhibited or destroyed Ae horizon development. Many CA2 soils display, in their lower sola and upper C horizons, clay films that are thought to be formed by pressure (e.g. freeze-thaw) rather than illuviation. Other soils occurring in small amounts are wet soils on seeps of depressional localities and Regosolic soils on steep, colluviating portions of the landscape. Lithic soil phases occur sporadically on CA2 but dominate on tracts mapped as CA2X.

A pedon illustrating Eluviated Dystric Brunisols of CA2 is described in Table 148. The upper part of the till parent material is more heterogeneous than normal for CA2 soils and is attributed to minor stratification. Sandy loam textures and quartzite fragments within the till reflect incorporation of material derived from Gog Group quartzites that dominate the upper reaches of Portal Creek valley in Jasper. Material derived from Miette Group slates and shales, that dominate the lower reaches of Portal Creek valley and underlie till at the sample site, is the major constituent of the till.

Vegetation

Vegetation of the CA2 Ecosite is dominated by the Engelmann spruce-subalpine fir/false azalea (C14), Engelmann spruce-subalpine fir/feathermoss (C13), and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s. The C14 v.t. is most abundant but on some tracts C13 or C21 dominates. The C14 v.t. occurs rarely in eastern Banff and Jasper. The C13 v.t. occurs more often at low elevations, on gentle slopes and in central to eastern areas of both parks. In northern Jasper and along the Continental Divide, C21 sometimes replaces C14 as the dominant v.t. Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) occur in minor amounts in central and eastern areas. Snow avalanche v.t.s, such as subalpine fir-willow (S2), occur on avalanched portions of the landscape. Fire affected vegetation, in which spruce is regenerating, occurs in some areas (e.g. north of Cascade Mountain in Banff). A plot representing vegetation of the pedon sample site and illustrating C14 on CA2 is described in Table 149.

Table 149 Stand (JE9180) illustrating the Engelmann spruce-subalpine fir/false azalea (C14) v.t. of the CA2 Ecosite.

TREE LAYER	
Abies lasiocarpa	15
Picea engelmannii	15
TALL SHRUB LAYER	
Abies lasiocarpa	08
Picea engelmannii	02
Pinus contorta	.5
Salix scouleriana	01
SHRUB LAYER	
Abies lasiocarpa	01
Juniperus communis	.5
Ledum groenlandicum	03
Menziesia glabella	20
Picea engelmannii	.5
Rhododendron albiflorum	.5
Shepherdia canadensis	01
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	.5
Cornus canadensis	01
Lycopodium annotinum	.5
Lycopodium complanatum	.5
Lycopodium obscurum	.5
Pinus contorta	.5
Vaccinium scoparium	02
Vaccinium vitis-idaea	.5
BRYOID LAYER	
Barbilophozia lycopodioides	.5
Cladonia mitis	.5
Cladonia coniocraea	.5
Cladonia cornuta	.5
Cladonia ecmocyna	01
Cladonia gonecha	.5
Cladonia gracilis	01
Dicranum polysetum	.5
Hylocomium splendens	25
Lecidea cinnabarina	.5
Lophozia spp.	.5
Ochrolechia androgyna	.5
Peltigera aphthosa	02
Peltigera canina	01
Pleurozium schreberi	30
Pohlia nutans	.5
Polytrichum commune	.5
Ptilium crista-castrensis	05
Ptilidium pulcherrimum	.5
Stereocaulon paschale	.5
Tritomaria exsectiformis	.5
EPIPHYTES	
Bryoria glabra	.5
Bryoria fuscescens	.5
Cetraria chlorophylla	.5
Cetraria pinastri	.5
Hypogymnia enteromorpha	.5
Hypogymnia physodes	.5
Parmelia sulcata	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE .5 INDICATES THE SPECIES WAS PRESENT

Discussion

The CA2 Ecosite is the most extensive of the Cavell Ecosites. In terms of physiographic position, landform surface expression, and vegetation, CA2 resembles the Bryant 1 and 2 (BY1, BY2), and Moraine Lake 1 (ML1) Ecosites. However, BY1 and BY2 occur on morainal landforms consisting of calcareous, medium textured till (Till C), and ML1 occurs on noncalcareous, coarse textured till (Till A) whereas CA2 occurs on Till B. Also BY1 and BY2 are dominated by Eutric Brunisols. The ML1 Ecosite is characterized by Dystric Brunisols with thicker sola and Ae horizons than CA2 soils. The CA2 is differentiated from other Cavell Ecosites by vegetation differences and amount of wet, seepage-affected landscape as outlined in Table 145. The Egypt 1 (EG1) Ecosite is the Upper Subalpine counterpart of CA2.

CA4 - CAVELL 4 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, CA4, occurs on morainal blankets consisting of noncalcareous, medium textured till (Till B) overlying inclined bedrock on valley walls. The soils normally occur in a pattern reflecting the degree of eluvial (Ae) horizon development. Eluviated Dystric Brunisols are dominant and Orthic Dystric Brunisols subdominant. Vegetation cover is dominated by the lodgepole pine/buffaloberry/twinflower (C19) and lodgepole pine/false azalea/grouseberry (C20) v.t.s. The CA4 Ecosite is more extensive in Jasper than in Banff.

Geomorphology

The CA4 Ecosite is typified by morainal blankets overlying inclined bedrock. The moraines consist of noncalcareous, medium textured till (Till B). Veneers of altered, medium textured eolian material (Eolian material B) occur sporadically and are very thin. Erosion following fires appears to have removed the eolian veneer from many tracts. The few CA4 tracts in the Bow River valley in Banff have more extensive Eolian material B veneers. Colluvium derived from till and fractured bedrock occurs occasionally on the steepest portions of the landscape. A medium textured variant of noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A), derived from slates and shales, occurs occasionally on valley floors and lower slopes.

Topographically, CA4 displays long, linear slopes consisting of till mantling the inclined bedrock that forms valley walls. Slopes commonly range from 15 to 70%. Gullied slopes occur associated with CA4 but much less frequently than with Panorama Ridge 1 and 2 (PR1, PR2) and Moraine Lake 2 (ML2) Ecosites. Colluvial blankets and veneers occur locally on the steepest terrain (>60%), particularly below bedrock escarpments. Tracts of CA4 situated along valley bottoms and shoulders, at valley confluences, in cirque basins and cols, and on failed slopes often display morainal landforms with irregular surfaces and complex topography (5-45% slopes). These landforms include morainal blankets and veneers overlying ridged and hummocky bedrock and the relatively deep till of hummocky moraines. Morainal veneers also occur on linear, inclined slopes and are dominant on tracts mapped as CA4X. Bedrock outcrops occur occasionally but are particularly common on CA4+R tracts.

Soils

The soils of the CA4 Ecosite are distributed in a pattern that reflects the degree of eluvial (Ae) horizon development. Eluviated Dystric Brunisols are dominant and Orthic Dystric Brunisols subdominant. These well drained soils have B horizons that range from moderately developed Bm horizons, at the till surface, to the strongly developed Bm and, infrequently, Bf horizons associated with altered, medium textured eolian (Eolian material B) veneers. Podzolic soils, generally Orthic Humo-Ferric Podzols, occur infrequently and are most common on CA4 tracts of western Banff. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly developed in the absence of Eolian material B. In some localities, recent surface disturbances such as windthrow of trees, avalanching, sheet erosion, and soil creep have inhibited or destroyed Ae horizon development. Many CA4 soils display, in lower sola and upper C horizons, clay films thought to be formed by pressure (e.g. freeze-thaw) rather than by illuviation. Other soils occurring in small amounts are wet soils on seeps of depressional localities and Regosolic soils on steep colluviating portions of the landscape. Lithic soil phases occur sporadically on tracts mapped as CA4 but dominate on CA4X tracts. A pedon illustrating Eluviated Dystric Brunisols of CA4 is described in Table 150.

Vegetation

Vegetation of the CA4 Ecosite is dominated by the lodgepole pine/buffaloberry/twinflower (C19) and lodgepole pine/false azalea/grouseberry (C20); v.t.s that reflect complex fire and successional histories within the Lower Subalpine. Lodgepole pine/green alder/feathermoss (C10) and lodgepole pine/buffaloberry/grouseberry (C18) are accessory v.t.s, with C10 occurring most often on cool, moist, northerly aspects at low elevations. Lodgepole pine/juniper/bearberry (C3) on subxeric sites, lodgepole pine/buffaloberry/showy aster

Table 150 Pedon (Alberta 1979 No. 34) description of an Eluviated Dystric Brunisol of the CA4 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: CA4.

LOCATION: MILITARY GRID REF. 11 ULJ 9855 6385; NTS MAP AREA 83D 15E.

CLIMATE: 1530 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN JUNE.

VEGETATION: VPN=JD9030*VTN=C20*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN, UNDIFFEPENTIATED OR UNDETERMINED; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), MORAINAL (TILL); LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 35% SIMPLE SLOPE OF CLASS 7 (31-45%), FACING SOUTH, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; SLIGHTLY STONY; EXCEEDINGLY ROCKY.

SPECIAL NOTES: SSN=GC9010*APN=015-019*PCF=1GR(2-4)2GR,2CB,2ST(5-6)*LFH=MG/RI*DATE=JUNE 26,1979*

L: 3 TO 0 CM, RANGE 1 TO 5 CM; 10YR 2/2; PLENTIFUL, MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AE: 0 TO 4 CM, RANGE 1 TO 8 CM; MATRIX MOIST 10YR 7/1; SILT LOAM; MODERATE, MEDIUM, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND MEDIUM ROOTS; MANY, VERY FINE PORES; IRREGULAR, CLEAR HORIZON BOUNDARY.

BM1: 4 TO 30 CM, RANGE 20 TO 35 CM; MATRIX MOIST 7.5YR 4/6; SANDY LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; FEW, VERY FINE PORES; 30% COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

BM2: 30 TO 35 CM, RANGE 0 TO 7 CM; MATRIX MOIST 7.5YR 7/8, MATRIX MOIST 7.5YR 7/4; SILT LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; COMMON, FINE PORES; 30% COARSE FRAGMENTS; BROKEN, CLEAR HORIZON BOUNDARY.

2BM: 35 TO 70 CM, RANGE 30 TO 40 CM; MATRIX MOIST 2.5Y 6.5/4; LOAM; MODERATE, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, VERY FINE ROOTS; COMMON, VERY FINE PORES; COMMON, MODERATELY THICK CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; 30% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2C: 70 TO 90 CM; MATRIX MOIST 2.5Y 6.5/4; LOAM; FEW, VERY FINE PORES; 30% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
L	3.7	41.60						
AE	4.3	0.80	9.5		2.5	0.4	0.1	0.1
BM1	4.8	0.90	6.6		1.8	0.8	-.1	0.1
BM2	5.3	1.10	6.3		1.0	0.1	-.1	0.1
2BM	4.7	0.40	3.3		0.5	0.2	-.1	0.1
2C	5.2		3.0		1.2	0.4	-.1	0.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
L				
AE				
BM1	0.1		0.1	
BM2	0.1		0.1	
2BM	0.1		-.1	
2C				

PHYSICAL DATA (SURVEY)

HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS % PASSING V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
L															
AE					3	10	11	11	8	43		50	7		
BM1					6	10	11	12	10	49		45	6		1.40
BM2					3	3	4	7	15	32		67	1		
2BM					7	9	8	10	7	41		45	14		2.10
2C		99	96	72	57	9	12	10	11	6	48		38	14		2.00

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	ENGINEERING SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
L													
AE		21.7	4.3										
BM1													
BM2		38.6	9.3										
2BM		18.5	4.1										
2C		17.1	5.1			9.0	19.0					24	08

(C6) and lodgepole pine/Labrador tea (C29) occur in minor amounts. A plot that represents vegetation of the pedon sample site (Table 150) and illustrates C20 on CA4 is presented in Table 151 and Plate 22.

Table 151 Stand (JD9030) illustrating the lodgepole pine/false azalea/grouseberry (C20) v.t. of the CA4 Ecosite.

TREE LAYER	
Pinus contorta	35
TALL SHRUB LAYER	
Pinus contorta	.5
Salix scouleriana	.5
SHRUB LAYER	
Abies lasiocarpa	.5
Menziesia glabella	45
Shepherdia canadensis	01
Salix spp.	01
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	.5
Cornus canadensis	.5
Linnaea borealis	.5
Spiraea lucida	05
Vaccinium membranaceum	30
BRYOID LAYER	
Barbilophozia lycopodioides	.5
Cetraria ericetorum	.5
Cladonia ecmocyna	20
Cladonia gracilis	.5
Cladonia phyllophora	25
Cladonia uncialis	.5
Dicranum brevifolium	01
Dicranum scoparium	01
Peltigera aphthosa	.5
Pleurozium schreberi	05
Polytrichum juniperinum	01
Psoroma hypnorum	.5
Stereocaulon tomentosum	01
EPIPHYTES	
Alectoria spp.	.5
Cetraria merrillii	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

In terms of physiographic position, landform surface expression, and vegetation, CA4 resembles the Panorama Ridge 1 and 2 (PR1, PR2), and Moraine Lake 2 (ML2) Ecosites. However, PR1 and PR2 occur on morainal landforms consisting of calcareous, medium textured till (Till C), and ML2 occurs on noncalcareous, coarse textured till (Till A) whereas CA4 occurs on Till B. The PR1 and PR2 Ecosites are dominated by Eutric Brunisols that display luvisolic tendencies. The ML2 is characterized by Dystric Brunisols with thicker sola and Ae horizons than CA4 soils. The CA4 Ecosection is differentiated from other Cavell Ecosites by vegetation differences and amount of wet, seepage-affected landscape as outlined in Table 145.

CN - CYCLONE ECOSECTION

The Cyclone (CN) Ecosection occurs on linear fluvial landforms comprised of either noncalcareous, coarse, stratified fluvial material (Fluvial material A) or calcareous, coarse, stratified fluvial material (Fluvial material B). Modification by snow avalanching and channeling is a common feature. The CN Ecosection is dominated by Regosolic soils associated with dry and moist shrub thickets.

The CN Ecosection occurs on lower slopes and valley floors in the Upper Subalpine portion of the Subalpine Ecoregion in both parks, mainly within the Front Ranges.

Only one Ecosite (CN1) is recognized within the CN Ecosection. Table 152 outlines the general features of the Cyclone 1 (CN1) Ecosection. Fig. 53 for the Tyrrell Ecosection shows the position of CN1 on the landscape.

CN1 - CYCLONE 1 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, CN1, is characterized by fluvial fans and aprons comprised of either noncalcareous, coarse, stratified fluvial material (Fluvial material A), or calcareous, coarse, stratified fluvial material (Fluvial material B). Modification by snow avalanching and channeling is common. Well to moderately well drained Orthic Regosols are most abundant. Vegetation is characterized by the willow-dwarf birch-shrubby cinquefoil (S10) and willow/hairy wild rye (S12) v.t.s.

Geomorphology

The CN1 Ecosite is characterized by fluvial fans and aprons comprised of either noncalcareous, coarse, stratified fluvial material (Fluvial material A) or calcareous, coarse, stratified fluvial material (Fluvial material B). Landforms comprised of Fluvial material B are more common. Modification by snow avalanching and channeling is common. The CN1 Ecosite is geomorphologically active and is subject to episodic flooding. Floodplains, terraces, and blankets are included on some CN1 tracts. Fluvial blankets usually overlie colluvial aprons and fans.

Topographically, CN1 is a gently sloping landform with linear slopes commonly ranging from 5 to 45%. Slopes <5% occur on fluvial floodplains and terraces.

Table 152 General features of the Cyclone 1 (CN1) Ecosite.

Ecosite	Landform	Soils	Vegetation
CN1	Fluvial material A,B; fan, apron	Regosolic	dry shrub thicket, moist shrub thicket

Table 153 Pedon (Alberta 1978 No. 51) description of a Cumulic Regosol of the CN1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: CUMULIC REGOSOL. SOIL MAP UNIT: NOTATION: CN1.

LOCATION: MILITARY GRID REF. 11 UNN 8210 680; NTS MAP AREA 820 12W.

CLIMATE: 2080 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 6 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JC8076*VTN=S12*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), FLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: FLUVIAL, COBBLY, AVALANCHED, FAN; SLOPE: 14% SIMPLE SLOPE OF CLASS 5 (10-15%), FACING NORTHEAST, SITE AT MIDDLE POSITION, MODERATELY MOUNDED MICROTOPOGRAPHY,400 M LONG; SOIL MOISTURE AND DRAINAGE: MODERATELY WELL DRAINED, RAPID SURFACE RUNOFF, SEEPAGE PRESENT; EXCEEDINGLY STONY.

SPECIAL NOTES: SSN=GC8031*APN=010-163*PCF=2AG(2)2AG(4)4AG(5)3AC(6)*LFH=FF*

LF: 6 TO 0 CM, RANGE 5 TO 10 CM; MATRIX MOIST 10YR 2/2; PLENTIFUL, MICRO ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK1: 0 TO 7 CM, RANGE 4 TO 10 CM; MATRIX MOIST 10YR 3/2; SILT LOAM; MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; FEW, FINE PORES; WEAK EFFERVESCENCE; WAVY, ABRUPT HORIZON BOUNDARY.

LFB: 7 TO 8 CM, RANGE 1 TO 2 CM; MATRIX MOIST 10YR 2/2; SILT LOAM; MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; FEW, VERY FINE PORES; WAVY, ABRUPT HORIZON BOUNDARY.

CKB1: 8 TO 16 CM, RANGE 5 TO 10 CM; MATRIX MOIST 10YR 2/2; SILT LOAM; MASSIVE STRUCTURE; WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; FEW, FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

CKB2: 16 TO 88 CM, RANGE 67 TO 77 CM; MATRIX MOIST 10YR 3/2; GRAVELLY SILT LOAM; MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, FINE ROOTS; MANY, MEDIUM PORES; MODERATE EFFERVESCENCE; VERY STRONGLY CALCAREOUS; ANGULAR GRAVELLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

CKB3: 88 TO 118 CM; MATRIX MOIST 10YR 3/2; SILT LOAM; MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, FINE PORES; WEAK EFFERVESCENCE; MODERATELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LF	6.5	38.00	3.9
CK1	7.0	3.20	15.3
LFB			
CKB1	7.1	5.50	8.6
CKB2	7.3	0.60	27.9
CKB3	7.0	1.70	12.0

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS													
	% PASSING										% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
CK1										22		65	13	
LFB														
CKB1										7		76	17	
CKB2	99			21						27		60	13	
CKB3	99	99	99	99						4		80	16	

PHYSICAL DATA

	MOISTURE STATUS (%)								ENGINEERING			
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTENBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
CK1		29.2	11.5										
LFB													
CKB1													
CKB2		18.3	8.4			22.0	26.0					12	
CKB3		26.3	9.0			33.0	57.0					40	09

Soils

Well to moderately well drained soils with little or no genetic horizon development dominate the CN1 Ecosite. Orthic Regosols are most abundant but a few tracts mapped as CN1 are dominated by Cumulic Regosols and Orthic Humic Regosols. These soils reflect incorporation of humus and modification by fluvial accretion. Geomorphic surfaces associated with Orthic Humic Regosols have remained stable long enough for development of relatively thick Ah horizons. The closely related Cumulic Humic Regosols occur in minor amounts. Ah horizon development has been interrupted by episodic flooding and fluvial aggradation in Cumulic Regosols. Orthic Eutric Brunisols are accessory soils that usually occupy slightly elevated, infrequently flooded portions of the landscape. Small amounts of gleyed soils occur where water tables are high along the lower margins of fans and aprons and on floodplains. A pedon illustrating Cumulic Regosols of CN1 is described in Table 153 and shown in Color Plate 14. This pedon was sampled in the upper Panther River valley in Banff. The dark colored horizons in this pedon are inherited from the dark colored shaly Mesozoic strata that occur upslope.

Vegetation

A variety of shrub dominated v.t.s and intergrades occur on tracts of CN1. They are best represented by the willow-dwarf birch-shrubby cinquefoil (S10) and willow/hairy wild rye (S12) v.t.s. The accessory v.t.s. willow-dwarf birch/fleabane (S4) and willow/cinquefoil (S8) occur and are probably associated with seasonally high water tables. Small amounts of the Engelmann spruce-subalpine fir/willow/hairy wild rye (O18) and dwarf birch-willow/kobresia (S9) v.t.s occur on some tracts. A plot illustrating the willow/hairy wild rye (S12) v.t. of the CN1 Ecosite is described in Table 154 and shown in Plate 60 and represents the vegetation at the pedon sample site described in Table 153.

Discussion

The CN1 Ecosite most resembles the Num-Ti-Jah 2 (NT2) Ecosite but the latter is differentiated by having imperfectly to poorly drained soils. The CN1 Ecosite may also appear to have similar vegetation to the Tyrrell 1 (TR1) Ecosite but the latter is differentiated by having better developed soils occurring on morainal deposits. The TR1 Ecosite is often mapped adjacent to CN1. Pipestone 6 and 7 (PP6, PP7) are the Lower Subalpine counterparts of CN1.

Table 154 Stand (JC8076) illustrating the willow hairy wild rye (S12) v.t. of the CN1 Ecosite.

SHRUB LAYER	
Betula glandulosa	25
Potentilla fruticosa	.5
Salix glauca	60
HERB-DWARF SHRUB LAYER	
Achillea millefolium	01
Agropyron smithii	01
Anemone parviflora	01
Aster ciliolatus	10
Astragalus alpinus	01
Delphinium glaucum	01
Elymus innovatus	25
Festuca saximontana	.5
Fragaria virginiana	.5
Hedysarum spp.	01
Senecio lugens	04
Solidago multiradiata	.5
Valeriana sitchensis	.5
Equisetum scirpoides	02
BRYOID LAYER	
Brachythecium groenlandicum	.5
Cladonia chlorophaea	.5
Drepanocladus uncinatus	.5
Hypnum revolutum	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

CP - COPPER ECOSECTION

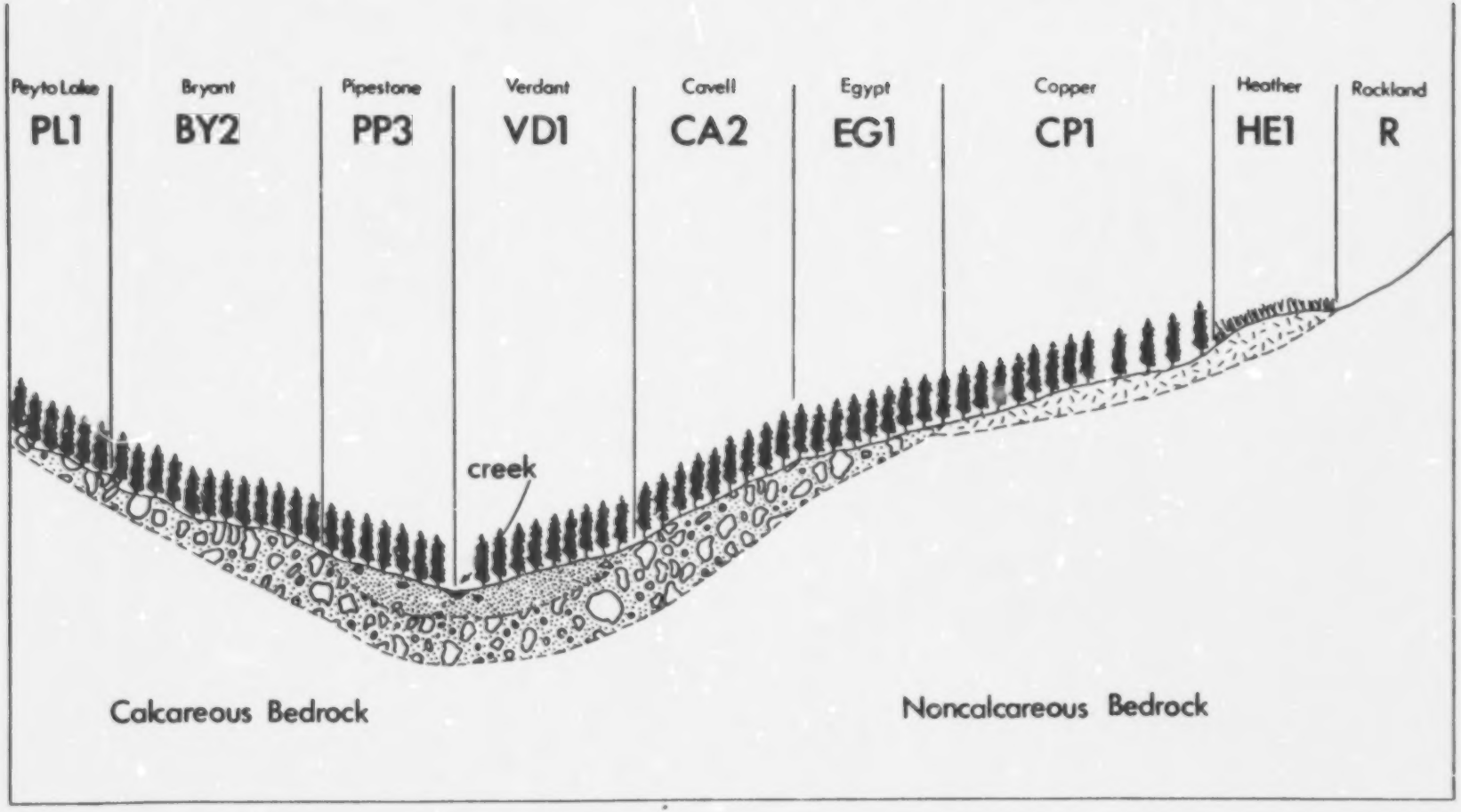
The Copper (CP) Ecosection is characterized by inclined, hummocky, and ridged terrain comprised of noncalcareous, medium textured residuum (Residuum A) derived from Miette Group strata in the Main Ranges and from Mesozoic strata in the Front Ranges. Some tracts of CP occur on failed bedrock. It is dominated by lithic Dystric Brunisols and Engelmann spruce-subalpine fir open and closed forests and subalpine larch-subalpine fir forest. The CP Ecosection occurs primarily on valley shoulders and spurs in the Upper Subalpine portion of the Subalpine Ecoregion in both parks.

Only one Ecosite (CP1) is recognized within the CP Ecosection and its general features are outlined in Table 155. Fig. 36 shows the CP1 Ecosite on the landscape in relation to other Ecosites.

Table 155 General features of the Copper 1 (CP1) Ecosite.

Ecosite	Landform	Soils	Vegetation
CP1	Residuum A; inclined, hummocky, ridged	lithic phase of Dystric Brunisol	Engelmann spruce-subalpine fir open and closed forests, subalpine larch subalpine fir forest

Figure 36 Landscape schematic showing the relationships of the Copper 1 (CP1) Ecosite to other Ecosites.



CP1 - COPPER 1 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, CP1, occurs on inclined, hummocky, and ridged terrain comprised of noncalcareous, medium textured residuum (Residuum A) derived from Miette Group strata in the Main Ranges and from Mesozoic strata in the Front Ranges subprovince. Some tracts of CP1 occur on failed bedrock. The CP Ecosite is dominated by well to moderately well drained lithic phases of Orthic and Eluviated Dystric Brunisols. Vegetation is dominated by the Engelmann spruce-subalpine fir/grouseberry (C15) and Engelmann spruce-subalpine fir/heather (O10) and subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t.s.

Geomorphology

The CP1 Ecosite occurs on inclined, hummocky, and ridged terrain comprised of noncalcareous, medium textured residuum (Residuum A). This residuum is derived from either the Miette Group in the Main Ranges or Mesozoic strata in the Front Ranges. The residuum weathers in situ with soils developing at the surface. Coarse fragment content increases with depth, usually to a lithic contact. Surficial veneers of altered, medium textured eolian material (Eolian material B) occur on CP1 in western Banff and sporadically elsewhere. Till erratics occur on some tracts.

Topographically, CP1 displays linear slopes on inclined terrain and complex slopes on hummocky and ridged terrain. Slopes commonly range between 15 and 60%. Hummocky terrain is more common on tracts of CP1 that are failed. These tracts have similar surface expression to landslides and old rock glaciers.

Soils

The soils of the CP1 Ecosite develop from weathered shales and slates. They reflect the noncalcareous nature and medium and fine texture of these lithologies. The CP1 Ecosite is characterized by well to moderately well drained, lithic phase Orthic and Eluviated Dystric Brunisols. Orthic Dystric Brunisols are dominant on most tracts. These soils are similar but separated taxonomically on thickness of the surface eluvial (Ae) horizon. Where altered, medium textured eolian material is present, Eluviated Dystric Brunisols and Orthic Humo-Ferric Podzols occur. Shale and slate fragment content and size increases with depth to a lithic contact. Orientation of the fragments in the weathering zone conforms to the original bedding planes of the underlying parent rock. Table 156 describes a pedon sampled in lower Pharoah Creek valley in Banff that illustrates an Orthic Dystric Brunisol of the CP1 Ecosite. Color Plate 15 shows this pedon.

Vegetation

The CP1 Ecosite is dominated by the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/heather (O10), and subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t.s. C15 and O10 are the most abundant v.t.s. The C23 v.t. dominates on a few tracts of CP1 in southern Banff. Minor amounts of the heather-everlasting (L5) and Engelmann spruce-subalpine fir/heather/feathermoss (C34) v.t.s also occur. A stand illustrating the C15 v.t. of the CP1 Ecosite is described in Table 157 and shown in Plate 99 and represents vegetation at the pedon sample site described above in Table 156.

Table 157 Stand (PA7185) illustrating the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. of the CP1 Ecosite.

TREE LAYER	
Abies lasiocarpa	20
Larix lyallii	06
Picea engelmannii	20
Pinus albicaulis	.5
TALL SHRUB LAYER	
Abies lasiocarpa	05
Larix lyallii	03
Picea engelmannii	02
SHRUB LAYER	
Abies lasiocarpa	10
Rhododendron albiflorum	.5
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	.5
Arnica latifolia	.5
Empetrum nigrum	05
Juniperus communis	01
Larix lyallii	.5
Ledum glandulosum	01
Picea engelmannii	.5
Vaccinium membranaceum	.5
Vaccinium scoparium	40
BRYOID LAYER	
Cladonia ecmocyna	20
Cladonia gonecha	.5
Dicranum polysetum	.5
Dicranum scoparium	40
Hylocomium splendens	.5
Peltigera aphthosa	02
Peltigera spp.	.5
Pleurozium schreberi	01
Barbilophozia lycopodioides	25
EPIPHYTES	
Alectoria sarmentosa	.5
Bryoria glabra	.5
Hypogymnia austerodes	.5
Letharia vulpina	.5
Parmeliopsis ambigua	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Table 156 Pedon (Alberta 1977 No. 139) description of an Orthic Dystric Brunisol of the CP1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: CP1.

LOCATION: MILITARY GRID REF. 11 UNG 7730 6850; NTS MAP AREA 82O 4W.

CLIMATE: 2190 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS POOR RELEVANCE TO THE SOIL SITE.

VEGETATION: VPN=PA7185+VTN=C15=.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), RESIDUAL, SHALE AND SLATE; LANDFORM CLASSIFICATION: BEDROCK, HUMMOCKY AND INCLINED; SLOPE: 30% COMPLEX SLOPE OF CLASS 7 (31-45%), FACING WEST, SITE AT MIDDLE POSITION, MODERATELY ROUGED MICROTOPOGRAPHY,10 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, SEEPAGE ABSENT; SLIGHTLY STONY; SLIGHTLY ROCKY.

SPECIAL NOTES: SS=WT7246+AP=703-67+RLU=10+PCF=30L(1-4)2A0.80L(5)=WEATHERING ALONG FRACTURES PRODUCES COMPLEX MOTTLE PATTERN(BLOTCHES)+LFH=RIH

LF: 6 TO 0 CM, RANGE 5 TO 8 CM

BM1: 0 TO 11 CM, RANGE 9 TO 13 CM; MATRIX MOIST 5YR 5/6, MATRIX MOIST 5YR 6/6; SILT LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; CHANNERY COARSE FRAGMENTS; SMOOTH, CLEAR HORIZON BOUNDARY.

BM2: 11 TO 32 CM, RANGE 16 TO 24 CM; MATRIX MOIST 10YR 5/6; SILT LOAM; MODERATE, COARSE, PLATY STRUCTURE PSEUDO; FRIABLE CONSISTENCE; FEW, FINE ROOTS; CHANNERY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

BC1: 32 TO 65 CM, RANGE 45 TO 55 CM; MATRIX MOIST 2.5Y 5/0; LOAM; MODERATE, COARSE, PLATY STRUCTURE PSEUDO; FRIABLE CONSISTENCE; VERY FEW, FINE ROOTS; CHANNERY COARSE FRAGMENTS; SMOOTH, GRADUAL HORIZON BOUNDARY.

BC2: 65 TO 115 CM, RANGE 55 CM; MATRIX MOIST 2.5Y 5/0; GRAVELLY FINE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; ANGULAR GRAVELLY AND CHANNERY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY; VERY STRONGLY ACID 4.6-5.0 FIELD PH.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	3.9	49.40						
BM1	4.1	3.30	12.2		0.7	0.4	<.1	0.2
BM2	4.4	0.60	6.9		4.0	0.8	<.1	0.1
BC1	4.5		6.7		1.4	0.9	<.1	0.1
BC2	4.7		4.4		2.7	1.5	<.1	0.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2
LF				
BM1	0.2		0.1	
BM2	0.1		<.1	
BC1				
BC2				

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 75-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
BM1					4	8	7	8	4	33		52	15	2
BM2					2	7	6	7	8	30		54	16	4
BC1					2	40	7	10	10	41		46	13	2
BC2		99	82	63	56	2	24	7	21	17	60		31	9

PHYSICAL DATA

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	ENGINEERING AASHO CLASS	UNIFIED CLASS
LF								
BM1								
BM2								
BC1	22.0	24.0					48	SP
BC2	21.0	22.0					24	SP

Table 158 General features of the Consolation Valley 1 (CV1) Ecosite.

Ecosite	Landform	Soils	Vegetation
CV1	Till A,B,C; blanket > sloping fen	Wet[80]: Gleysolic, gleyed Podzolic, Organic Dry[20]: Eutric and Dystric Brunisol	Wet[80]: wet spruce open forest, wet Engelmann spruce-subalpine fir open forest > wet shrubby meadow, birch fen Dry[20]: Engelmann spruce-subalpine fir forest, lodgepole pine forest

Discussion

The CP1 Ecosite most closely resembles the Whitehorn 2 (WH2) and Endless Chain 1 (EN1) Ecosites in terms of landform surface expression, soils, and vegetation. However, WH1 and EN1 occur on Colluvium B and A respectively and distinguishes them from CP1 which occurs on Residuum A. The CP1 Ecosite may also resemble Whitehorn 1 (WH1) in southern Banff where the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. occurs but can be distinguished by the colluvial material associated with the latter. Failed tracts of CP1 may appear similar to Boulder Pass 1 and 2 (BP1, BP2) Ecosites but the latter occur on landslide materials. The Brazeau 1 and 2 (BZ1, BZ2) are the Lower Subalpine counterparts of CP1.

CV - CONSOLATION VALLEY ECOSECTION

The Consolation Valley Ecosection is complex and encompasses dominantly wet, seepage affected, morainal landforms throughout the Lower Subalpine portion of the Subalpine Ecoregion in Banff and Jasper. Inclined, ridged, and hummocky surface expressions are characteristic and reflect bedrock control, glacial deposition, or slope failure. The moraines consist of noncalcareous, medium textured till (Till B), the low lime phase of calcareous, medium textured till (Till C), and occasionally, noncalcareous, coarse textured till (Till A). The subdominant landforms consist of sloping fens that thinly mantle the till on the wettest localities. A wet-dry landscape pattern governed by drainage and seepage conditions is characteristic. This pattern is comprised of about 80% wet (poorly to very poorly drained, hygric to hydric) segments and 20% dry (well to moderately well drained, mesic) segments.

A complex set of genetically related Gleysolic, gleyed Podzolic, and Organic soils occur on the wet segments. Distribution of these soils is related to degrees of gleying and saturation, and the presence of primary mineral-bearing surface veneers. Wet Engelmann spruce-subalpine fir open forest, wet spruce open forest, wet shrubby meadow, and birch fen best characterize the vegetation of CV1 wet segments. The open forest vegetation is most extensive. Brunisolic soils occurring under Engelmann spruce-subalpine fir or lodgepole pine forests dominate the dry segments. Table 158 summarizes the characteristics of the one Consolation Valley Ecosite (CV1).

The CV Ecosection normally occurs on the floors and adjacent lower slopes of narrow valleys and on lower valley walls and adjacent upper benchland slopes in broad valleys (Figure 37). These positions correspond to major zones of groundwater discharge within a valley hydrologic system. Wetness is attributed to water supply rather than to poor soil permeability as exemplified in the Merlin Castle (MC) Ecosection. Seeps and seepage are characteristic and occur throughout the thaw season. Dry segments occupy localities where the fluctuating water table rarely reaches the control section.

The CV Ecosection is more extensive in the Main Ranges than in the Front Ranges. In the Front Ranges it usually occurs on broad valley floor benchlands where the unconsolidated glacial deposits are underlain by Mesozoic shales and sandstone. In the Main Ranges, CV usually occurs on lower valley wall slopes and valley floors including benchlands where the glacial deposits are underlain by the Miette Group slates and shales. Groundwater flow patterns appear to be affected by these strata, thus contributing to high water tables and seepage.

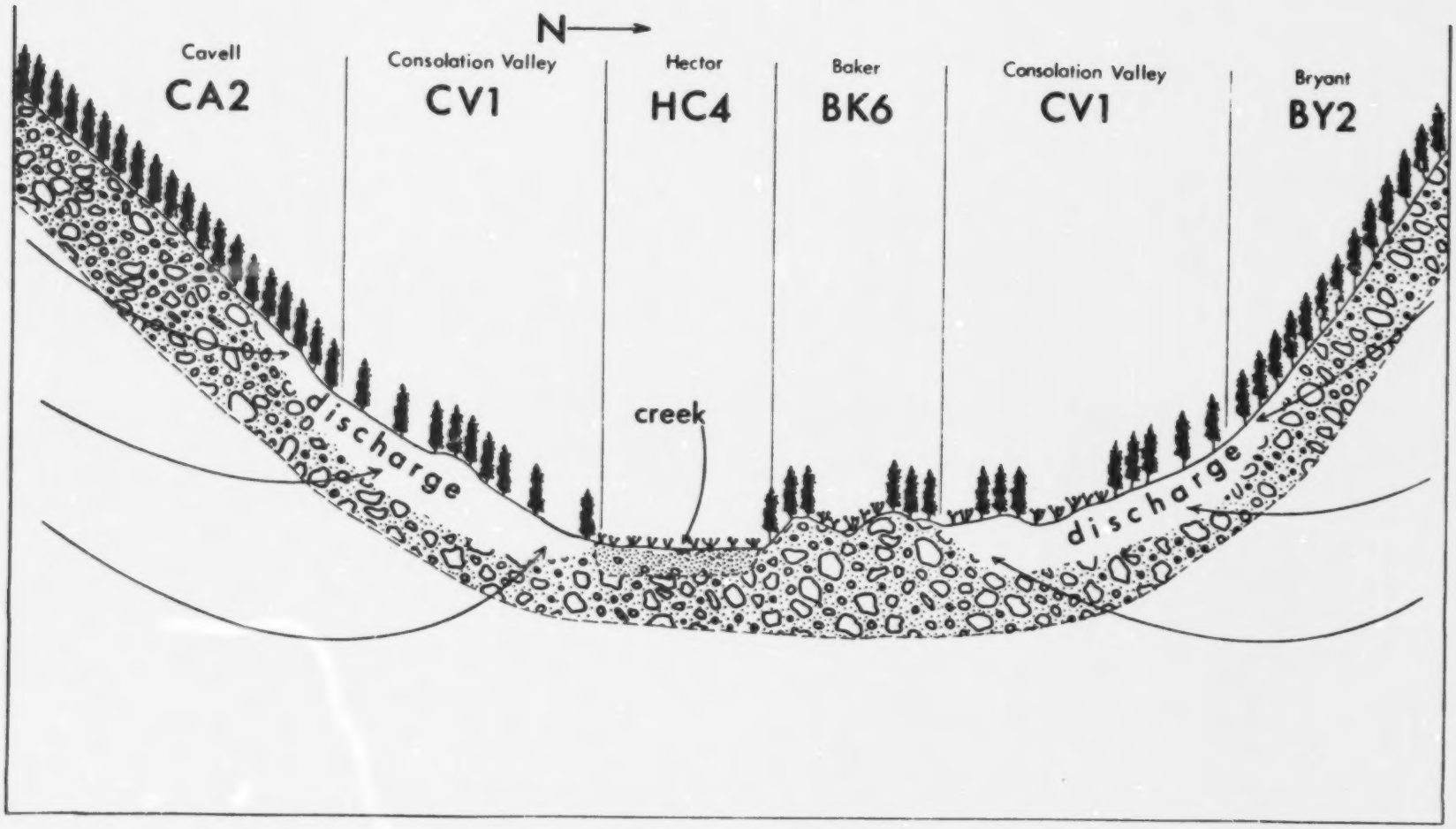
CV1 - CONSOLATION VALLEY 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, CV1, encompasses dominantly wet, seepage affected morainal landforms displaying inclined, ridged, or hummocky surfaces. These moraines consist of noncalcareous, medium textured till (Till B), the low lime phase of calcareous, medium textured till (Till C), and occasionally, noncalcareous, coarse textured till (Till A). Inclined surfaces usually reflect the underlying bedrock. Hummocky and ridged surfaces reflect bedrock control, glacial deposition, or post depositional slope failure. The subdominant landform consists of sloping fens that thinly mantle the till on the wettest localities. A wet > dry landscape pattern governed by drainage and seepage conditions is characteristic. This pattern is comprised of about 80% wet (poorly to very poorly drained, hygric to hydric) segments and 20% dry (well to moderately well drained, mesic) segments.

A complex set of genetically related soils, best represented by the Orthic Gleysol, Rego Gleysol, Gleyed Ferro-Humic Podzol, and Terric Mesisol Subgroups, occurs on the wet segments. Distribution of these soils is related to degrees of gleying and saturation, and the presence of mineral surface veneers. Vegetation of wet segments is also complex and is best represented by a pattern in which the spruce/Labrador tea/brown moss (O11) and Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14) v.t.s are dominant, and the dwarf birch-shrubby cinquefoil-willow/brown moss (S1) and dwarf birch-shrubby cinquefoil/needlerush (S3) v.t.s are subdominant. Eluviated Eutric Brunisols or Elu-

Figure 37 Landscape schematic showing the relationship of the Consolation Valley 1 (CV1) Ecosite to other Ecosites.



viated Dystric Brunisols dominate the dry segments. This soil distribution is governed by calcareousness and reaction of the parent material. Spruce or lodgepole pine forest, best represented by the Engelmann spruce-subalpine fir/feathermoss (C13), lodgepole pine/false azalea/grouseberry (C20), and lodgepole pine/Labrador tea (C29) v.t.s, dominate the dry segments.

Geomorphology

The CV1 Ecosite is typified by morainal landforms consisting of noncalcareous, medium textured till (Till B), the low lime (weakly to moderately calcareous) phase of calcareous, medium textured till (Till C), and in a few areas, noncalcareous, coarse textured till (Till A). The higher lime end member of Till C also occurs occasionally. Glacial landforms consisting of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) or, rarely, noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A) are important along some valley floors (e.g. east end of Shadow Lake in Banff). Parent material textures are predominantly medium (silt loam to loam to sandy loam) and less frequently coarse (sandy loam to loamy sand to sand), or fine (clay loam to silty clay loam to silty clay). Wet segments are usually thinly mantled by peat derived primarily from sedges and brown mosses (e.g. *Tomenthypnum nitens* and *Aulacomnium palustre*). This fen peat, rarely exceeding 1.2 m in thickness, is mainly moderately decomposed but fibric and humic layers also occur. Occasionally wood fragments may be found. Where the peat is >40 cm thick, the landform is classified as sloping fen (C.S.S.C. 1978b) recognizing that in some localities fen vegetation has been succeeded by open forest. Within the control section the fen peat is underlain by till, or occassionally, by noncalcareous, coarse, stratified fluvial material (Fluvial material A), calcareous, coarse, stratified fluvial material (Fluvial material B), altered, medium textured eolian material (Eolian material B), or altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) veneers. The fluvial and fluviolacustrine veneers may contain reworked material originally deposited as Eolian material B veneers. On some sites, Eolian material B containing ash is preserved in thin layers at or near the base of the organic layer. Eolian material B veneers also occur on the dry segments and are most extensive in western Banff and southwestern Jasper. The unconsolidated materials of CV1 are usually underlain, at variable depth, by Precambrian or Mesozoic strata.

Topographically, CV1 displays linear (inclined) to irregular (hummocky or ridged) slopes on lower valley walls and valley floors including benchlands. Slopes commonly range from 5 to 45%. Inclined slopes generally reflect the underlying bedrock surfaces. Hummocky and ridged surfaces reflect underlying bedrock surfaces, glacial deposition, or post depositional slope failure. Failed till slopes on CV1 tracts are usually seepage-induced rotational slumps. Extinct rock glaciers and apron-like landforms consisting of till that has undergone flow (e.g. lower slopes of Bow River valley near Mosquito Creek in Banff) also occur. Slope failure status may be active or inactive. Morainal veneers and bedrock outcrops rarely occur.

Soils

Soils of the CV1 Ecosite are distributed in a pattern governed by drainage and seepage conditions. A complex set of pedogenically related soils, best represented by the Orthic Gleysol, Rego Gleysol, Gleyed Ferro-Humic Podzol, and Terric Mesisol Subgroups, occurs on the wet segments. Strength of gleying, reflecting degree of movement and aeration of seepage waters, is variable. The accesory soils, Gleyed Eutric Brunisols and Gleyed Dystric Brunisols, occur on sites where gleying is weakly expressed. Prolonged periods of saturation give strongly gleyed soils with little or no pedogenic horizonation (Rego Gleysols). In some localities, recent or continuing fluvial and soil flow activities have inhibited or destroyed horizon development. Orthic Gleysols and Gleyed Ferro-Humic Podzols occur in localities with shorter periods of saturation. The presence of eolian and fluviolacustrine veneers containing primary minerals promotes the development of iron, aluminum, and humus enriched B and podzolic B horizons (usually Bhf and podzolic Bhf). Soils with such horizons are most common in western Banff and southwestern Jasper. Favorable moisture, nutrient, and vegetation conditions have resulted in the accumulation of varying thicknesses of fen peat on most wet segment soils. Terric Mesisols occur where the peat is >40 cm thick. Other organic soils with subdominant humic or fibric layers and Humic Gleysols occur occasionally.

A pedon illustrating Terric Mesisols of wet segments of CV1 is described in Table 159. The sample site is shown in Plate 100. This pedon is developed in organic material, containing two thin layers of Eolian material B, overlying Till A. A pedon illustrating Rego Gleysols of CV1 wet segments is described in Table 160. This pedon is developed in organic material, containing one relatively thick layer of Eolian material B, overlying Till B. A low amount of calcium carbonate has been infused into these profiles by seepage. The upward increase in lime content in the Terric Mesisol profile suggests that the site is affected by groundwater discharge.

Table 159 Pedon (Alberta 1975 No. 110) description of a Terric Mesisol of wet segments of the CV1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: TERRIC MESISOL, SOIL MAP UNIT: NOTATION: CV1.

LOCATION: MILITARY GRID REF. 11 UNG 5770 9260; NTS MAP AREA 82N 8E.

CLIMATE: 1850 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS GOOD RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 8 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: VPN=K55091*VTN=014*.STAND SAMPLED ABOUT 50M NW OF PEDON SAMPLING SITE*.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, STRATIFIED (MINERAL AND ORGANIC), WEAKLY CALCAREOUS (1 TO 6% CACO3), ORGANIC, A430; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, SANDY, WEAKLY CALCAREOUS (1 TO 6% CACO3), MORAINAL (TILL); LANDFORM CLASSIFICATION: FEN, SLOPING; SLOPE: 18% SIMPLE SLOPE OF CLASS 6 (16-30%), FACING NORTHEAST, SITE AT UPPER SLOPE POSITION; SOIL MOISTURE AND DRAINAGE: VERY POORLY DRAINED, MODERATELY PERVIOUS, SEEPAGE PRESENT; NONSTONY; NONROCKY.

SPECIAL NOTES: SS#=JTS004*APN=A1765S-145*REPRESENTATIVE SITE.SOIL BIT MORE HUMIFIED + CUMULIZED THAN MODAL*ORGANIC PARENT MATERIAL CONTAINS TWO EOLIAN (ASH) LAYERS*COARSE FRAGMENTS PRESENT IN TILL BUT NOT DESCRIBED*.

OF: 0 TO 20 CM, RANGE 17 TO 20 CM; HORIZON WET; MATRIX MOIST 10YR 2/2; MATERIAL COMPOSITION 1% FEATHERMOSS, SLIGHT DECOMPOSITION; WAVY, CLEAR HORIZON BOUNDARY; SLIGHTLY ACID 6.1-6.5 FIELD PH.

OM1: 20 TO 40 CM, RANGE 19 TO 23 CM; HORIZON WET; MATRIX MOIST 10YR 2/1; MATERIAL COMPOSITION 1% FEATHERMOSS, MODERATE DECOMPOSITION; WAVY, ABRUPT HORIZON BOUNDARY; SLIGHTLY ACID 6.1-6.5 FIELD PH.

CG1: 40 TO 42 CM, RANGE 1 TO 3 CM; HORIZON WET; MATRIX MOIST 10YR 5/8; SILT LOAM; MASSIVE STRUCTURE; SLIGHTLY STICKY, VERY FRIABLE, SLIGHTLY PLASTIC CONSISTENCE; WAVY, ABRUPT HORIZON BOUNDARY; SLIGHTLY ACID 6.1-6.5 FIELD PH.

OM2: 42 TO 59 CM, RANGE 16 TO 20 CM; HORIZON WET; MATRIX MOIST 10YR 2/1; MATERIAL COMPOSITION 1% FEATHERMOSS, HIGH AND MODERATE DECOMPOSITION; WAVY, ABRUPT HORIZON BOUNDARY; SLIGHTLY ACID 6.1-6.5 FIELD PH.

CG2: 59 TO 65 CM, RANGE 5 TO 10 CM; HORIZON WET; MATRIX MOIST 5YR 4/8; ASHY SILT LOAM; MASSIVE STRUCTURE; SLIGHTLY STICKY, VERY FRIABLE, SLIGHTLY PLASTIC CONSISTENCE; WAVY, ABRUPT HORIZON BOUNDARY; SLIGHTLY ACID 6.1-6.5 FIELD PH.

OM3: 65 TO 73 CM, RANGE 8 TO 14 CM; HORIZON WET; MATRIX MOIST 10YR 2/1; MATERIAL COMPOSITION MODERATE AND HIGH DECOMPOSITION; SLIGHTLY HARD WOODY MATERIAL 7 CM THICK, 10-20% BY VOLUME; WAVY, ABRUPT HORIZON BOUNDARY; SLIGHTLY ACID 6.1-6.5 FIELD PH.

2CG1: 73 TO 82 CM, RANGE 7 TO 12 CM; HORIZON WET; MATRIX MOIST 10YR 6/1; LOAMY FINE SAND; FEW, COARSE, PROMINENT, 5YR 4/8 MOTTLES, MASSIVE STRUCTURE; SLIGHTLY STICKY, VERY FRIABLE, NONPLASTIC CONSISTENCE; WAVY, CLEAR HORIZON BOUNDARY; NEUTRAL 6.6-7.3 FIELD PH.

2CG2: 82 TO 105 CM; HORIZON WET; MATRIX MOIST 2.5Y 6/4; LOAMY FINE SAND; MANY, COARSE, PROMINENT, 7.5YR 5/8 MOTTLES; MANY, COARSE, PROMINENT, 10R 6/1 MOTTLES; MASSIVE STRUCTURE; SLIGHTLY STICKY, VERY FRIABLE, NONPLASTIC CONSISTENCE; NEUTRAL 6.6-7.3 FIELD PH.

PHYSICAL DATA (SURVEY)

		PARTICLE SIZE ANALYSIS												
		X PASSING				X OF SAMPLE								
HORIZON		3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
OF															
OM1															
CG1											39		55	6	
OM2															
CG2											21		72	7	
OM3															
2CG1						2	7	21	42	18	82		14	4	
2CG2						2	5	19	42	13	81		15	4	

CHEMICAL DATA (SURVEY)

HORIZON		PH 1	ORG C (%)	CALC CARB EQU.%
OF		7.0	34.59	2.5
OM1		6.6	35.00	2.0
CG1		6.3	7.40	
OM2		6.1	34.30	
CG2		6.5	2.30	1.8
OM3		6.2	19.50	
2CG1		6.7	0.00	1.8
2CG2		6.7	0.00	1.4

Eluviated Eutric and Dystric Brunisols best represent soils of CV1 dry segments. Eluviated Eutric Brunisols occur on Till C, Eluviated Dystric Brunisols on Till A or Till B. Orthic Eutric and Dystric Brunisols are important accessory soils occurring where eluvial (Ae) horizons are weakly developed or absent. These soils are most abundant where Eolian material B veneers are absent or surface erosion has recently occurred. Regosolic soils occur on severely eroded localities. Small amounts of Luvisolic soils occur on Till C.

Vegetation

Vegetation of the CV1 Ecosite is distributed in a pattern governed by drainage and seepage conditions. Wet segment vegetation is complex and is best represented by a secondary pattern in which the spruce/Labrador tea/brown moss (O11) and Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14) v.t.s are dominant, and the dwarf birch-shrubby cinquefoil-willow/brown moss (S1) and dwarf birch-shrubby cinquefoil/needlerush (S3) v.t.s are subdominant. The O11 v.t. is most extensive at low elevations (1350-1750 m). The O14 v.t. favors high elevations and steeper slopes and is more abundant in Banff. Few Organic soils occur under O14. The S1 and S3 v.t.s. occur as small patches usually confined to gently sloping benches and depressions within CV1 tracts. On a few CV1 tracts, S1 and S3

Table 160 Pedon (Alberta 1977 No. 115) description of a Rego Gleysol of wet segments of the CV1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: REGO GLEYSOL. SOIL MAP UNIT: NOTATION: CV1. SOIL PHASES: PEATY.

LOCATION: MILITARY GRID REF. 11 UMJ 3375 6100; NTS MAP AREA 83C 13*.

CLIMATE: 1550 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS MODERATE RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 40 CM IN SEPTEMBER, NO. 2 WAS 4 DEG(C) AT 10 CM IN SEPTEMBER.

VEGETATION: VPN=IC70%*VTN=CB*.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, UNDIFFERENTIATED, ORGANIC, ORGANIC MATERIAL (UNDIFFERENTIATED); PARENT MATERIAL 2: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), EOLIAN, UNDIFFERENTIATED OR UNDETERMINED; PARENT MATERIAL 3: UNSPECIFIED WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), WEAKLY CALCAREOUS (1 TO 6% CACO3), MORAINAL (TILL), SHALE AND QUARTZITE; ORGANIC DEPOSIT IS 0.2 M; LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 18% SIMPLE SLOPE OF CLASS 5 (10-15%), FACING NORTHEAST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,600 M LONG; SOIL MOISTURE AND DRAINAGE: POORLY DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE PRESENT; NONSTONY; NONROCKY; PRESENT LAND USE: UNPRODUCTIVE WOODLAND; HUMUS-FORM: PEATYMORS AND HUMIC, HYDRIC, MESOTROPHIC, THIN.

SPECIAL NOTES: SSN=RW710I*APN=015-110*PCF=3GR,3CB(5-6)*LFH=MB/MI

OH: 14 TO 9 CM, RANGE 3 TO 5 CM; HORIZON MOIST; NATURAL WET/OXIDIZED 2.5Y 2/1, NATURAL WET/OXIDIZED 5YR 3/2; MATERIAL COMPOSITION 1 AND 1 AND 1 AND 1 AND 1 AND 1% SEDGE AND REED AND HERBACEOUS FRAGMENTS AND WOOD FRAGMENTS AND LEAVES AND NEEDLES AND FEATHERMOSS, MODERATE DECOMPOSITION; SOFT WOODY MATERIAL 0 CM THICK; ORGANIC; ABUNDANT, FINE AND MEDIUM, RANDOM ROOTS; SMOOTH, CLEAR HORIZON BOUNDARY.

OH: 9 TO 0 CM, RANGE 9 TO 20 CM; HORIZON WET; NATURAL WET/OXIDIZED 2.5Y 2/1; MATERIAL COMPOSITION HIGH DECOMPOSITION; VON POST SCALE 09; ORGANIC; NONSTICKY CONSISTENCE; ABUNDANT, FINE AND MEDIUM, RANDOM ROOTS; SMOOTH, CLEAR HORIZON BOUNDARY.

CG: 0 TO 28 CM, RANGE 15 TO 28 CM; HORIZON MOIST; NATURAL WET/OXIDIZED 2.5Y 4/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE, RANDOM ROOTS; SMOOTH, CLEAR HORIZON BOUNDARY.

OHB: 28 TO 30 CM, RANGE 1 TO 3 CM; HORIZON WET; NATURAL WET/OXIDIZED 2.5Y 2/0; ORGANIC; NONSTICKY CONSISTENCE; PLENTIFUL, FINE, VERTICAL ROOTS; SMOOTH, CLEAR HORIZON BOUNDARY.

2CG1: 30 TO 61 CM, RANGE 30 TO 32 CM; HORIZON MOIST; NATURAL WET/OXIDIZED 2.5Y 5/4, NATURAL WET/OXIDIZED 5Y 5/3; LOAM; FEW, FINE, PROMINENT, 2.5YR V/C NOT RECORDED MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; GRAVELLY AND COBBLY COARSE FRAGMENTS; SMOOTH, CLEAR HORIZON BOUNDARY.

2CG2: 61 TO 82 CM; HORIZON MOIST; MATRIX MOIST 5Y 5/3; LOAM; FEW, FINE, PROMINENT MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; FIRM CONSISTENCE; GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
OH1	6.8	37.70	0.6
OH	6.5	27.00	0.6
CG	6.7		0.1
OHB			
2CG1	6.9		0.1
2CG2	7.4		1.1

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS												
	% PASSING				% OF SAMPLE								
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-20U SILT	50-20U SILT	2U CLAY	0.2U CLAY
OH														
OH														
CG					1	2	4	9	20	36		50	14	4
OHB														
2CG1					4	8	11	13	7	43		40	17	4
2CG2	99	96	86	80	5	10	11	14	8	48		34	16	7

CHEMICAL DATA (SURVEY)

	EXTRACT IRON (%)		EXTRACT ALUMINUM (%)	
HORIZON	1	2	1	2
OH				
OH				
CG	0.1		-.1	
OHB				
2CG1	0.1		-.1	
2CG2	-.1		-.1	

PHYSICAL DATA

	ENGINEERING							
HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
OH								
OH								
CG								
OHB								
2CG1								
2CG2	15.0	22.0		12.0	1.9		40	18

are dominant or codominant in relation to the wet open forest vegetation. These tracts (e.g. Snake Indian River valley in the Willow Creek area in Jasper, east end of Shadow Lake in Banff) occur on valley floor benchlands and have, like the Baker Creek (BK) Ecosection, a more pronounced hummocky and ridged relief than normal. Wet depressional segments of these tracts commonly have thin fluvial deposits.

Black spruce-lodgepole pine/willow/sedge (C8) and Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6) are important accessory v.t.s. The C8 v.t. occurs occasionally at low elevations on northerly aspects throughout Jasper. The C8 v.t. is usually abundant to the point of dominance or codominance on a few CV1 tracts in the lower Maligne River valley and the Athabasca River valley below Mt. Fryatt. The O6 v.t. is common on fluvial modified localities with gentle slopes throughout both parks. Intergrades of the above v.t.s, Engelmann spruce-subalpine fir/valerian-fleabane (O9), water sedge-beaked sedge (H11), and other moist to wet shrubby v.t.s occur in small amounts. Modification of the CV1 vegetation by recent fires has occurred in some areas (e.g. Siffleur River valley in Banff). On some of these CV1B tracts, lodgepole pine has replaced spruce in the open forest vegetation.

A stand illustrating O14 of CV1 wet segments is described in Table 161. This stand is located about 50 m northwest of the pedon sample site described in Table 159 and is shown in the background of Plate 100.

A variety of Lower Subalpine spruce and pine forest v.t.s occur on the dry segments of CV1. Distribution is related to fire histories. Being dominantly wet, CV1 is not as frequently or severely affected by fire as other, often adjacent, Lower Subalpine Ecosites. Consequently, spruce forest, usually Engelmann spruce-subalpine fir/feathermoss (C13) correlating to valley floor and lower slope positions, most often dominates dry segments. Occasionlly, Engelmann spruce-subalpine fir/false azalea (C14) is common on relatively steep slopes of mid to lower valley walls. Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) and Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) occur sporadically. In areas where fire occurred, lodgepole pine forest, best represented by the cool, moist lodgepole pine/false azalea/grouseberry (C20) and lodgepole pine/Labrador tea (C29) v.t.s, dominates dry segments. Lodgepole pine/feathermoss (C11), lodgepole pine/buffaloberry/grouseberry (C18), and lodgepole pine/buffaloberry/twinflower (C19) are also common in some areas. Modification of these spruce and pine v.t.s by recent fires has occurred in some areas (CV1B tracts).

Table 161 Stand (KS5091) illustrating the Engelmann spruce-subalpine fir/rock willow/bracted lousewort (014) v.t. of wet segments of the CV1 Ecosite.

TREE LAYER	
Abies lasiocarpa	05
Picea engelmannii	20
Pinus contorta	10
TALL SHRUB LAYER	
Abies lasiocarpa	15
Picea engelmannii	05
SHRUB LAYER	
Abies lasiocarpa	10
Betula glandulosa	12
Ledum groenlandicum	04
Lonicera involucrata	.5
Menziesia glabella	03
Picea engelmannii	05
Potentilla fruticosa	02
Salix barrattiana	01
Salix farrae	03
Salix vestita	30
HERB-DWARF SHRUB LAYER	
Anemone parviflora	02
Carex scirpoidea	05
Carex vaginata	25
Cassiope mertensiana	02
Cornus canadensis	01
Empetrum nigrum	02
Erigeron peregrinus	03
Kalmia polifolia	03
Linnaea borealis	.5
Parnassia fimbriata	01
Pedicularis bracteosa	.5
Phyllodoce glanduliflora	04
Polygonum viviparum	.5
Pyrola elliptica	.5
Senecio triangularis	.5
Stenanthium occidentale	02
Trisetum spicatum	.5
Vaccinium scoparium	20
Viola renifolia	.5
Equisetum arvense	03
BRYOID LAYER	
Aulacomnium palustre	10
Barbilophozia hatcheri	.5
Barbilophozia lycopodioides	08
Cladonia spp.	01
Dicranum spp.	02
Drepanocladus uncinatus	05
Hylocomium splendens	20
Peltigera aphthosa	01
Pleurozium schreberi	10
Sphagnum warnstorfii	03
Sphagnum spp.	.5
Tomenthypnum nitens	02
EPIPHYTES	
Cetraria tilesii	.5
Alectoria spp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The CV1 Ecosite is broad in concept and encompasses all dominantly wet terrain occurring on morainal landforms in the Lower Subalpine. It encompasses a compound landscape pattern consisting of poorly to very

poorly drained, seepage affected segments and randomly to orderly distributed, well to moderately well drained, dry segments that are not significantly affected by seepage. The proportion of dry segments on CV1 commonly ranges from 5 to 30%. Wet segments are much larger versions of the wet depressional segments contained in the Baker Creek (BK) and Cavell 1 (CA1) Ecosites. In a few cases, CV1 wet segments resemble the Hector 1 and 4 (HC1, HC4) Ecosites. Dry segments resemble the Bryant (BY), Panorama Ridge 1, 2, 3, or 6 (PR1, PR2, PR3, PR6), Cavell 2 or 4 (CA2, CA4), or Moraine Lake 1 or 2 (ML1, ML2) Ecosites. Map presentation of CV1 tracts at scales larger than 1:50,000 is invalid because the wet and dry segments would become mappable as separate Ecosites. In terms of landscape pattern, CV1 resembles the Merlin Castle 1 (MC1) Ecosite. The MC1 Ecosite however, occurs on calcareous, fine textured glaciolacustrine veneers and blankets overlying glacial landforms and is generally restricted to the lower portions of valley floor benchlands with gentle slopes adjacent to river channels. Wetness on MC1 is primarily attributed to surface accumulations of water on slowly pervious soils rather than groundwater discharge and seepage in CV1. The MC1 Ecosite has significantly less Organic soils and slightly different vegetation cover. Sphinx 2 (SX2) is the Upper Subalpine equivalent of CV1 but is dominantly wet, usually lacking a significant proportion of dry areas. There is no Montane counterpart of CV1.

DV - DEVONA ECOSECTION

The Devona (DV) Ecosection encompasses a ridged (dune) landform comprised of calcareous, medium textured eolian material (Eolian material A) occurring in the Montane Ecoregion. Regosolic soils associated with moist white spruce forest and shrubby grassland typify DV. The DV Ecosection is only mapped in Jasper and occurs in the center of the valley floor of the Athabasca River, mainly adjacent to Jasper Lake and northeast to Jasper's East Gate.

Two Ecosites (DV1, DV2) are recognized in the DV Ecosection and are separated primarily on vegetational differences. Table 162 outlines the general features of DV. Fig. 38 shows, schematically, the DV1 Ecosite on the landscape.

DV1 - DEVONA 1 ECOSITE

Ecosite Concept

The Montane Ecosite, DV1, encompasses a ridged (dune) landform comprised of calcareous, medium textured eolian material (Eolian material A). Soils are dominantly Orthic Regosols. Vegetation is characterized by the creeping juniper-northern wheatgrass-sedge (L6) v.t.

Geomorphology

The DV1 Ecosite encompasses ridged, elongate (dune) landforms comprised of calcareous, medium textured eolian material (Eolian material A). The dunes are postglacial deposits derived from the shores of Jasper Lake and the Athabasca River floodplain at low water periods and owe their existence to periodic strong winds which are funneled down the Athabasca River valley (Plate 101). The dunes are up to 25 m deep between Jasper and Talbot Lakes where the majority of DV1 is mapped, but become considerably thinner north and east from Jasper Lake. Actively blowing materials and occasional blowouts on the windward side of the dunes affect less than 10% of DV1. Topographically, DV1 dislays complex slopes commonly ranging from 5 to 30%.

Soils

The DV1 Ecosite is dominated by rapidly drained, extremely calcareous Orthic Regosols that are mainly located immediately east of Jasper Lake where some active wind erosion and deposition still takes place. These soils are free of coarse fragments and vary in texture from very fine sandy loam near source areas adjacent to Jasper Lake, gradually changing to silt loam on landforms in the downwind easterly direction from the source. A pedon illustrating Orthic Regosols of DV1 is described in Table 163.

Vegetation

The DV1 Ecosite is dominated by the creeping juniper-northern wheatgrass-sedge (L6) v.t. which occurs on the drier, exposed portions of these dunes. The moister depressions between the dunes support white spruce thickets, an important associate of the L6 v.t.

Table 162 General features of the Devona (DV) Ecosites.

Ecosite	Landform	Soils	Vegetation
DV1	Eolian material A; ridged	Regosol	shrubby grassland
DV2	Eolian material A; ridged	Regosol	moist white spruce forest

Figure 38 Landscape schematic showing the relationship of the Devona 1 (DV1) Ecosite to other Ecosites.

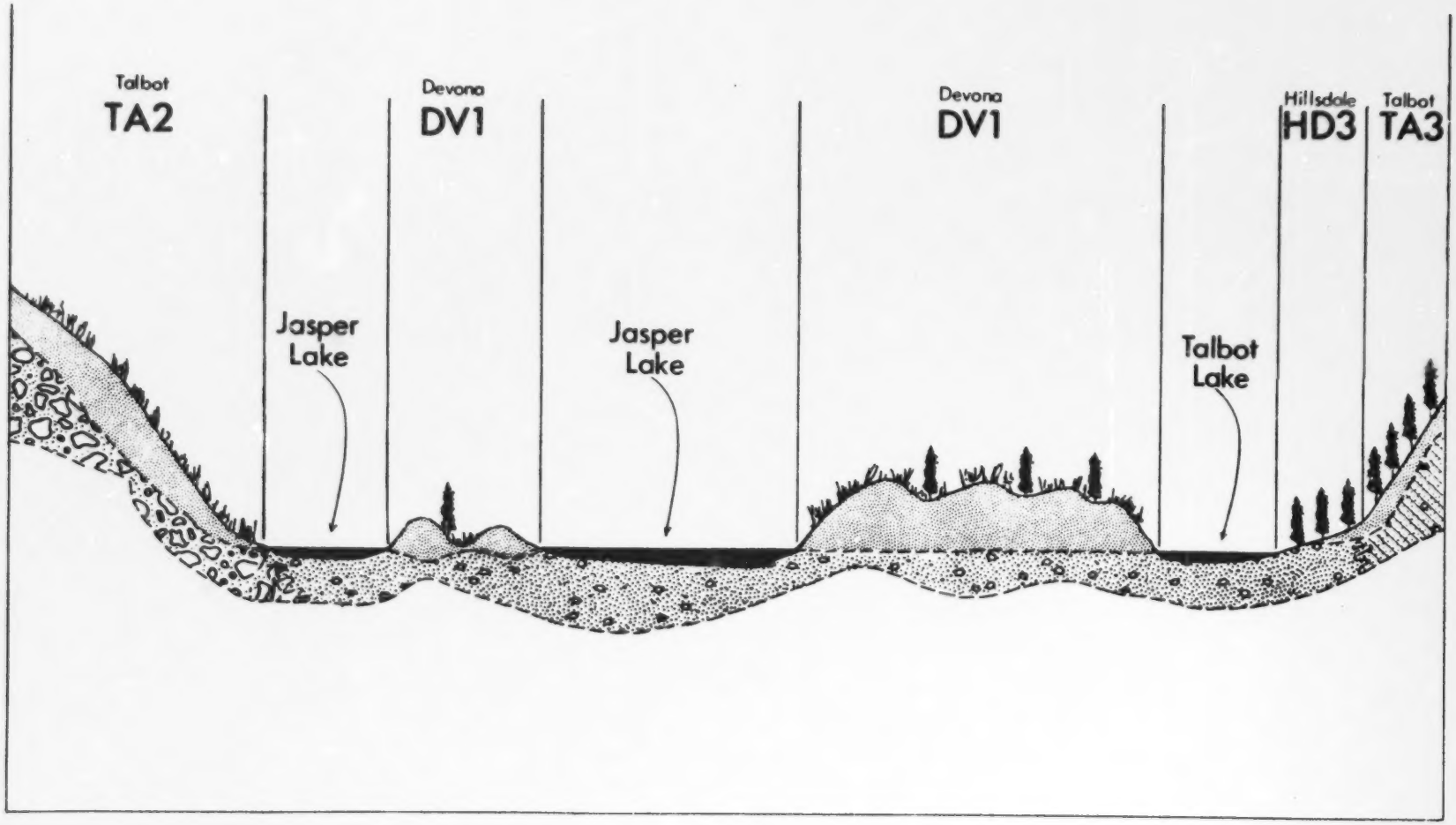


Table 163 Pedon (Alberta 1976 No. 66) description of an Orthic Regosol of the DV1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC REGOSOL. SOIL MAP UNIT: NOTATION: DV1.

LOCATION: MILITARY GRID REF. 11 UMJ 2995 8085; NTS MAP AREA 83E 1E.

CLIMATE: 1000 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS GOOD RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 15 DEG(C) AT 50 CM IN AUGUST.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), EOLIAN, UNDIFFERENTIATED OR UNDETERMINED; LANDFORM CLASSIFICATION: EOLIAN, RIDGED; SLOPE: 15% COMPLEX SLOPE OF CLASS 8 (10-15%), FACING EAST, SITE AT CREST POSITION, 10 M LONG; SOIL MOISTURE AND DRAINAGE: SEMIARID, WIND ERODED ; NONSTONY; NONROCKY.

SPECIAL NOTES: SSN=JT6024*APH=015-137*LFH=ER*

ACK: 0 TO 10 CM, RANGE 7 TO 11 CM; MATRIX MOIST 10YR 3/2, MATRIX MOIST 10YR 4/2; VERY FINE SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE, NONPLASTIC CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, GRADUAL HORIZON BOUNDARY.

CK: 10 TO 50 CM; MATRIX MOIST 10YR 5/2; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE, NONPLASTIC CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	TOTAL N (%)	CALC CARB EQU.%
ACK	7.5	0.10	0.10	56.5
CK	7.6	-.10		59.5

PHYSICAL DATA

	ENGINEERING						
HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
ACK								
CK	0.0	0.0					40	09

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS													
	% PASSING				% OF SAMPLE									
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-20U SILT	50-20U SILT	2U CLAY	0.2U CLAY
ACK					0	0	2	34	34	70		27	3	
CK					0	0	1	20	32	53		45	2	

Junegrass-pasture sage-wild blue flax (H6) occurs as an accessory v.t. on DV1. The L6 and H6 v.t.s. have been important in the stabilization of these dunes. *Stipa comata* commonly occurs on DV1 but is rare elsewhere in Banff and Jasper. Unvegetated localities occur where wind erosion is active, producing blowouts. These are commonly found on southerly aspects close to the source material. A plot illustrating the L6 v.t. of DV1 is described in Table 164. Plate 102 shows the vegetation and landscape of DV1. Plate 103 shows a blowout area on DV1 near the north end of Jasper Lake.

Discussion

The DV1 Ecosite may resemble the Talbot 2 (TA2) Ecosite where they both support the H6 v.t. The DV1 Ecosite is differentiated by having much deeper deposits, and is separated from DV2 primarily on vegetational differences as outlined in Table 162. DV1 is mapped only in Jasper.

DV2 - DEVONA 2 ECOSITE

Ecosite Concept

The Montane Ecosite, DV2, encompasses ridged, elongate (dune) landforms comprised of calcareous, medium textured eolian material (Eolian material A). Soils are dominantly Orthic and Cumulic Regosols. Vegetation is dominated by the white spruce/prickly rose/fern moss (C27) v.t. Tracts of DV2 occur on both sides of the Athabasca River valley between the north end of Jasper Lake and Jasper's East Gate.

Table 164 Stand (JC7037) illustrating the creeping juniper-wheatgrass-sedge (L6) v.t. of the DV1 Ecosite.

SHRUB LAYER	
Juniperus horizontalis	20
Potentilla fruticosa	02
HERB-DWARF SHRUB LAYER	
Agropyron inerme	10
Arctostaphylos uva-ursi	01
Artemisia frigida	01
Artemisia michauxiana	02
Campanula rotundifolia	01
Carex scirpoidea	30
Gaillardia aristata	01
Hedysarum mackenzii	02
Koeleria cristata	05
Linum lewisii	02
Senecio cymbalarioides	.5
Zygadenus elegans	.5
BRYOID LAYER	
Barbula acuta	.5
Campylium chrysophyllum	.5
Ditrichum flexicaule	.5
Hypnum cupressiforme	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Table 165 Pedon (Alberta 1978 No. 17) description of a Cumulic Regosol of the DV2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: CUMULIC REGOSOL. SOIL MAP UNIT: NOTATION: DV2.

LOCATION: MILITARY GRID REF. 11 UMJ 3900 9632; NTS MAP AREA 83F 4W.

CLIMATE: 1010 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS MODERATE RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 1 DEG(C) AT 40 CM IN MAY, NO. 2 WAS 0 DEG(C) AT 70 CM IN MAY, NO. 3 WAS 0 DEG(C) AT 120 CM IN MAY.

VEGETATION: VPN=JM8001*VTN=C27*.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), EOLIAN, UNDIFFERENTIATED OR UNDETERMINED; LANDFORM CLASSIFICATION: EOLIAN, RIDGED; SLOPE: 0% COMPLEX SLOPE OF CLASS 1 (0-0.5%), FACING LEVEL, SITE AT CREST POSITION, LEVEL MICROTOPOGRAPHY,; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, RAPIDLY PERVIOUS, SEEPAGE ABSENT; NONSTONY; NONROCKY; PRESENT LAND USE: OUTDOOR RECREATION.

SPECIAL NOTES: SSN=RW8002*APN=010-005*PROFILE FREE OF COARSE FRAGMENTS*ACK HORIZON IS ACTUALLY AHK*CK COMPLEX*LFH=ER*

LF: 3 TO 0 CM, RANGE 3 TO 4 CM; HORIZON MOIST; SMOOTH, ABRUPT HORIZON BOUNDARY.

ACK: 0 TO 16 CM, RANGE 14 TO 18 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 3/2, MATRIX MOIST 10YR 3/2; SILT; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM AND COARSE ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, DENDRITIC, TUBULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, CLEAR HORIZON BOUNDARY.

CK1: 16 TO 22 CM, RANGE 6 TO 10 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/2; SILT; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, DENDRITIC, TUBULAR PORES; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; SMOOTH, CLEAR HORIZON BOUNDARY.

BMKB: 22 TO 28 CM, RANGE 0 TO 10 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 4/4; SILT; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, DENDRITIC, TUBULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; BROKEN, ABRUPT HORIZON BOUNDARY.

AHKB: 28 TO 33 CM, RANGE 4 TO 7 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 3/2; SILT; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, DENDRITIC, TUBULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, CLEAR HORIZON BOUNDARY.

CK2: 33 TO 85 CM, RANGE 45 TO 55 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/2; SILT LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, DENDRITIC, TUBULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, GRADUAL HORIZON BOUNDARY.

CK3: 85 TO 140 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/2; SILT LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; FEW, MEDIUM ROOTS; FEW, FINE, RANDOM, CONTINUOUS, DENDRITIC, TUBULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LF			
ACK	7.6	6.10	44.1
CK1	7.7	3.20	34.9
BMKB	7.4	0.20	47.2
AHKB	7.4	0.00	40.5
CK2	7.7		47.3
CK3	7.6		49.2

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2
LF		
ACK		
CK1		
BMKB	-.1	
AHKB		
CK2		
CK3		

PHYSICAL DATA (SURVEY)

PARTICLE SIZE ANALYSIS

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
ACK										9		83	8	
CK1										13		80	7	
BMKB										12		81	7	
AHKB										11		81	8	
CK2										14		78	8	
CK3	99	99	99	99						15		79	6	

ENGINEERING

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
ACK													
CK1		15.0	6.7										
BMKB													
AHKB													
CK2		11.0	4.1										
CK3		8.4	3.4			0.0	0.0					4b	1B

Geomorphology

The DV2 Ecosite encompasses ridged, elongate (dune) landforms comprised of calcareous, medium textured eolian material (Eolian material A). These dunes occur farther from the source and aggrade at a lesser rate than DV1. Topographically, the dunes of DV2 are not as well developed as those of DV1. The DV2 Ecosite displays complex slopes commonly ranging from 5 to 15% and reflects variation in soil and vegetation that indicate periods of stability mixed with periods of depositional activity.

Soils

The DV2 Ecosite is dominated by Orthic and Cumulic Regosols. These well to rapidly drained soils are extremely calcareous, free of coarse fragments and vary in texture from very fine sandy loam to silt loam. They are still actively aggrading though at a slower rate than DV1. This slower aggradation of loessial materials on DV2 is reflected by Cumulic Regosols with buried Ahk horizons which developed via a process of physical mixing and accretion (Dumanski and Pawluk 1971). A pedon illustrating Cumulic Regosols of DV2 is described in Table 165.

Vegetation

The DV2 Ecosite is dominated by the white spruce/prickly rose/fern moss (C27) v.t. The calciphile *Thuidium abietinum* is the predominant moss in the understory of C27 and reflects the presence of carbonates at the surface. Creeping juniper-northern wheatgrass-sedge (L6) occurs as an accessory v.t. and usually occurs on more open exposed localities within DV2 tracts. A stand illustrating the C27 v.t. of DV2 is described in Table 166 and shown in Plate 28. This stand represents the vegetation near the pedon sample site described above in Table 165.

Discussion

In terms of vegetation cover, soils, and surficial deposits, the DV2 Ecosite most resembles the Talbot 3 (TA3) Ecosite. However, DV2 has much deeper deposits than TA3. The surface expression of TA3 reflects underlying genetic material.

The DV2 Ecosite is separated from DV1 primarily on vegetation differences as outlined in Table 162. DV2 is mapped only in Jasper; however, Rutter (1972) describes a small area of sand dunes three kilometers northeast of Banff townsite. These dunes are small in areal extent and are part of a tract mapped as NY3 with a 5c slope.

Table 166 Stand (JM8001) illustrating the white spruce/prickly rose/fern moss (C27) v.t. of the DV2 Ecosite.

TREE LAYER	
Picea glauca	27
TALL SHRUB LAYER	
Picea glauca	05
Salix bebbiana	.5
SHRUB LAYER	
Amelanchier alnifolia	01
Lonicera dioica	01
Picea glauca	01
Rosa acicularis	22
Shepherdia canadensis	05
HERB-DWARF SHRUB LAYER	
Achillea millefolium	.5
Aquilegia jonesii	01
Arctostaphylos uva-ursi	01
Aster ciliolatus	.5
Astragalus spp.	.5
Carex concinna	05
Carex eburnea	02
Carex richardsonii	.5
Elymus innovatus	23
Fragaria virginiana	.5
Galium boreale	.5
Gentiana amarella	.5
Geocaulon lividum	01
Goodyera repens	.5
Hedysarum mackenzii	01
Linnaea borealis	03
Oryzopsis asperifolia	.5
Pyrola asarifolia	.5
Pyrola secunda	02
Rubus pubescens	.5
Smilacina stellata	.5
Viola adunca	.5
Viola renifolia	.5
Zygadenus elegans	.5
Equisetum arvense	01
BRYOID LAYER	
Brachythecium spp.	.5
Entodon concinnus	.5
Hypnum cupressiforme	.5
Pohlia cruda	.5
Leptogium furfuraceum	.5
Orthotricum spp.	.5
Peltigera canina	.5
Physcia subobscura	.5
Physconia farrea	.5
Pylaisiella polyantha	02
Thuidium abietinum	07
Thuidium recognitum	.5
Tortella tortuosa	.5
Tortula ruralis	02

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

EF - EIFFEL ECOSECTION

The Eiffel Ecosection encompasses morainal landforms comprised of noncalcareous, coarse textured till (Till A) in the Alpine Ecoregion of Banff and Jasper (Plate 104). It occurs in the Main Ranges primarily on valley walls and shoulders, cirque basins, and cols in areas that are geologically dominated by Cambrian Gog Group quartzites.

Table 167 General features of the Eiffel 1 (EF1) Ecosite.

Ecosite	Landform	Soils	Vegetation
EF1	Till A: blanket, veneer	Dystric Brunisol, Sombric Brunisol, Ferro-Humic Podzol	heath tundra

Dystric and Sombric Brunisols and Podzols characterize the soil component of EF. These well drained, deeply weathered, well developed soils reflect the acidic, coarse textured parent material, humus accumulation in upper sola and the presence of altered, medium textured eolian (Eolian material B) veneers in cool, moist conditions. The vegetation component is dominated by heath tundra and reflects stable landforms in the moist, cool Alpine environment of the Main Ranges. Table 167 summarizes the characteristics of the one Eiffel Ecosite (EF1). Fig. 43 shows, schematically, the position of EF1 in relation to the Larch Valley (LV) and Moraine Lake (ML) Ecosites.

EF1 - EIFFEL 1 ECOSITE

Ecosite Concept

The Alpine Ecosite, EF1, occurs on morainal blankets and veneers consisting of noncalcareous, coarse textured till (Till A) overlying inclined, hummocky, and ridged bedrock. Soils of the EF1 Ecosite, namely Orthic Dystric Brunisols, Eluviated Dystric Brunisols, Orthic Sombric Brunisols, and Orthic Ferro-Humic Podzols, are well developed, deeply weathered, and well drained. Their development reflects acidic, coarse textured parent material, humus accumulation in upper sola, and the presence of altered, medium textured eolian material (Eolian material B) veneers. The vegetation component is dominated by heather-everlasting (L5) and reflects stable landforms in the cool, moist Alpine environment of the Main Ranges.

Geomorphology

The EF1 Ecosite is typified by morainal blankets and veneers overlying inclined, hummocky, or ridged bedrock. These moraines consist of noncalcareous, coarse textured till (Till A). The low lime phase of Till A rarely occurs. Veneers of altered, medium textured eolian material (Eolian material B) occur extensively on EF1 tracts of western Banff and southwestern Jasper, sporadically elsewhere. Colluvium derived from till and fractured bedrock is found occasionally on the steepest portions of the landscape.

Topographically, EF1 is typified by inclined slopes on valley walls and hummocky or ridged surfaces on valley shoulders, cirque basins, and cols. Bedrock control of surface expression is characteristic. Failed slopes (EF1F) occur, including old rock glaciers, and usually have hummocky surfaces that do not necessarily reflect underlying bedrock surfaces. Slopes commonly range from 5 to 45%. Morainal veneers dominate on EF1X tracts. Bedrock escarpments occur sporadically but are abundant on EF1+R tracts. Patches of colluvial blankets and veneers occur occasionally on the steepest terrain, particularly below bedrock escarpments. The EF1 Ecosite surfaces are often more stony than surfaces on any other morainal Ecosite (Plate 104).

Soils

Orthic Dystric Brunisols, Eluviated Dystric Brunisols, Orthic Sombric Brunisols, and Orthic Ferro-Humic Podzols characterize the soils component of EF1. These well drained soils have thick, well developed sola that reflect the acidity and highly pervious coarse textures of the till parent material. Under the Alpine conditions, humus incorporation into upper sola is significant and the effects of eluviation are often masked, particularly where altered, medium textured eolian material (Eolian material B) is present. Thus, EF1 soils have varying thicknesses of Ah and/or Ahe horizons. Where Eolian material B veneers are very thin or absent, Ahe and Ae horizons are more likely to develop. Where these eolian veneers are present, the soils often have Bhf or podzolic Bhf horizons above, and Bm horizons below the parent material disconformity. Weak cementation (duric tendencies) in lower Bm and BC horizons may occur. Soils with Bf and podzolic Bf horizons, Eluviated Sombric Brunisols, and Sombric Ferro-Humic Podzols also occur occasionally. Lithic soil phases are associated with the morainal veneers. These dominate on EF1X tracts. Turbic phases, produced primarily by solifluction on steep slopes, occur occasionally but are less abundant than on the Molar Pass 1 (MP1) and Jonas 1 (JN1) Ecosites. Seeps with wet soils occur occasionally in depressional localities.

A pedon illustrating Orthic Ferro-Humic Podzols of EF1 is described in Table 168 and shown in Color Plate 16. The upper solum is developed in a mixture of Eolian material B and Till A.

Vegetation

The vegetation of EF1 is dominated by the heather-everlasting (L5) v.t. Accessory v.t.s are mountain avens-snow willow-moss campion (H1) and white mountain heather-mountain

Table 168 Pedon (Alberta 1979 No. 48) description of an Orthic Ferro-Humic Podzol of the EF1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC FERRO-HUMIC PODZOL. SOIL MAP UNIT: NOTATION: EF1.

LOCATION: MILITARY GRID REF. 11 UNJ 3935 8560; NTS MAP AREA 83C 13.

CLIMATE: 2180 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=PA9120+VTN=LS.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND SKELETAL (>35% OF PARTICLES 2-25 CM), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), MORAINAL (TILL), SEDIMENTARY; LANDFORM CLASSIFICATION: ACTIVE MORAINAL, GRAVELLY, DEFLATED, BLANKET; SLOPE: 5% COMPLEX SLOPE OF CLASS 5 (10-15%), FACING SOUTH, SITE AT CREST POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,100 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; EXCESSIVELY STONY.

SPECIAL NOTES: SSN=GC9070+APN=015-026+PCF=3GR,2CB,3ST(1-3)3GR,3CB,3ST(4-7)+DATE=SEPT.10,1979+UPPER THREE HORIZONS DEVELOPED IN A MIXTURE OF EOLIAN MATERIAL AND TILL.

AH: 0 TO 8 CM, RANGE 6 TO 10 CM; MATRIX MOIST 7.5YR 3/2; LOAM; WEAK, FINE, GRANULAR STRUCTURE; FRIABLE CONSISTENCE; ABUNDANT, VERY FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 8 TO 18 CM, RANGE 8 TO 5 CM; MATRIX MOIST 7.5YR 4/2; LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; COMMON, FINE PORES; BROKEN, ABRUPT HORIZON BOUNDARY.

BHF: 18 TO 25 CM, RANGE 18 TO 28 CM; MATRIX MOIST 2.5YR 2/4; SILT LOAM; WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; MANY, VERY FINE PORES; WAVY, ABRUPT HORIZON BOUNDARY.

2AE: 25 TO 66 CM, RANGE 38 TO 58 CM; MATRIX MOIST 7.5YR 6/0; LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; WEAK, COARSE, PLATY SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, MICRO ROOTS; COMMON, FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

2BM: 66 TO 88 CM, RANGE 18 TO 16 CM; MATRIX MOIST 2.5YR 4/6, MATRIX MOIST 7.5YR 5/6; SANDY LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE PORES; WAVY, GRADUAL HORIZON BOUNDARY.

2BM: 88 TO 110 CM, RANGE 26 TO 35 CM; MATRIX MOIST 7.5YR 6/6; FINE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; FRIABLE CONSISTENCE; FEW, FINE PORES; WAVY, GRADUAL HORIZON BOUNDARY.

2C: 110 TO 125 CM; MATRIX MOIST 10YR 6/6; FINE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; FRIABLE CONSISTENCE; .

CHEMICAL DATA (SURVEY)

HORIZON		PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
AH		4.6	15.40	31.4		5.1	0.1	<.1	0.4
AE									
BHF		4.9	8.30	49.2		1.4	0.8	<.1	0.1
2AE		5.4	3.00	1.2		0.6	0.1	<.1	<.1
2BM		5.5	2.00	1.3		0.3	0.1	0.1	<.1
2BM		5.1	2.00	0.6		0.2	0.0	<.1	<.1
2C		5.2		0.3		0.1	0.0	<.1	<.1

CHEMICAL DATA (SURVEY)

HORIZON		EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
AH					
AE					
BHF		0.6		0.9	
2AE					
2BM		0.2		<.1	
2BM		0.1		<.1	
2C					

PHYSICAL DATA (SURVEY)

HORIZON		3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS % PASSING V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 78-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
AH						8	7	19	19	8	43		46	11		
AE																
BHF						1	2	5	7	10	25		74	3		0.60
2AE						10	12	19	26	11	78		20	2		1.70
2BM						8	11	16	21	9	65		31	4		
2BM						5	7	16	24	9	59		36	5		
2C		99	69	34	48	7	8	13	24	11	61		35	4		2.10

PHYSICAL DATA

HORIZON		ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AH									
AE									
BHF									
2AE									
2BM									
2BM									
2C								12	07

avens-snow willow (L4). The H1 v.t. occurs on some of the more exposed, wind-swept, ridge and hummock crests. The L4 v.t. occurs in later snow lie localities on northerly aspects. Black alpine sedge-everlasting (H2) occurs occasionally on even later snow lie and meltwater runoff sites. Depressional localities with seeps have moist to wet v.t.s. Up to 20% krummholz and tree islands are included along lower boundaries of some EF1 tracts. A plot representing vegetation of the pedon sample site described above (Table 168) and illustrating L5 on EF1 is described in Table 169.

Table 169 Stand (PA9129) illustrating the heather-everlasting (L5) v.t. of the EF1 Ecosite.

HERB-DWARF SHRUB LAYER	
Antennaria lanata	.5
Arctostaphylos rubra	.5
Carex scirpoidea	.5
Cassiope mertensiana	02
Cassiope tetragona	10
Dryas octopetala	02
Empetrum nigrum	10
Phyllodoce glanduliflora	45
Salix arctica	.5
Salix nivalis	.5
Vaccinium vitis-idaea	01
Lycopodium alpinum	.5
BRYOID LAYER	
Cetraria hepatizon	.5
Cetraria islandica	.5
Cetraria nivalis	03
Cetraria tilesii	.5
Cladonia mitis	.5
Cladonia ecmocyna	.5
Cladonia gracilis	.5
Cladonia uncialis	.5
Conostomum tetragonum	01
Dicranum scoparium	02
Lepraria neglecta	.5
Polytrichum piliferum	02
Pohlia spp.	01
Rhizocarpon geographicum	10
Solorina crocea	.5
Umbilicaria hyperborea	05
Thamnolia sp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 05 INDICATES THE SPECIES WAS PRESENT

Discussion

In terms of physiographic position, landform surface expression, and vegetation cover, EF1 resembles the Molar Pass 1 (MP1) and Jonas 1 (JN1) Ecosite. The MP1 Ecosite however, occurs on morainal landforms consisting of calcareous, medium textured till (Till C); JN1 occurs on noncalcareous, medium textured till (Till B). The MP1 Ecosite has Eutric and Melanic Brunisols, and Regosolic soils under mountain avens-snow willow-moss campion (H1) and heather-everlasting (L5) vegetation. Soils of the JN1 Ecosite are similar to EF1 soils but are distributed in a different pattern. Vegetation of JN1 includes significant amounts of H1 in addition to L5. The Larch Valley 2 (LV2) Ecosite is the Upper Subalpine counterpart of EF1.

EG - EGYPT ECOSECTION

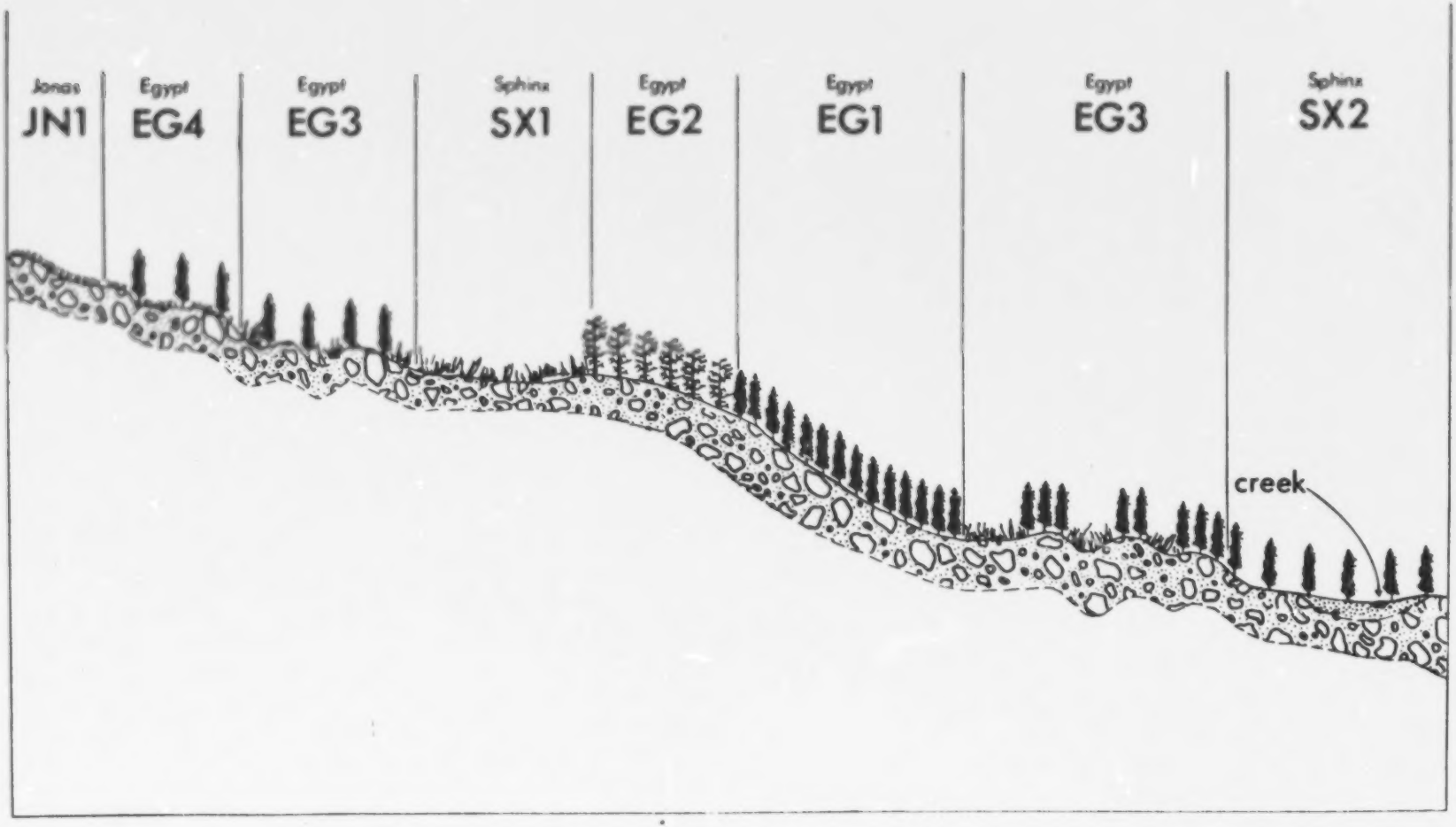
The Egypt Ecosection encompasses morainal landforms comprised of noncalcareous, medium textured till (Till B) in the Upper Subalpine portion of the Subalpine Ecoregion in Banff and Jasper. The EG Ecosection occurs most extensively in the Main Ranges in association with the Miette Group. It also occurs in the Front Ranges in association with noncalcareous Mesozoic strata. Valley walls, floors, and shoulders, cirque basins, and cols are common physiographic positions in which EG occurs.

The dominant soils, Dystric Brunisols, are moderately developed and reflect the noncalcareous, medium textured parent material and cool, moist Upper Subalpine vegetation. Two groups of coniferous closed and open forest, a pattern of tundra plus coniferous open forest, and a dry > wet landscape pattern differentiate the four Egypt (EG) Ecosites (Table 170). Fig. 39 shows, schematically, the physiographic positions of the Egypt Ecosites

Table 170 General features of the Egypt (EG) Ecosites.

Ecosite	Landform	Soils	Vegetation
EG1	Till B; blanket	Dystric Brunisol	Engelmann spruce-subalpine fir closed and open forests
EG2	Till B; blanket	Dystric Brunisol > Humo-Ferric Podzol	subalpine larch-subalpine fir forest
EG3	Till B; blanket, veneer	Dry[m]: Dystric Brunisol	Dry[m]: Engelmann spruce-subalpine fir closed and open forests, subalpine larch-subalpine fir forest
		Wet[m]: Gleysolic, gleyed Podzolic and Brunisolic	Wet[m]: Engelmann spruce-subalpine fir open forest, moist herb meadow
EG4	Till B; blanket	Dystric Brunisol > Sombric Brunisol, Ferro-Humic Podzol	heath tundra > Engelmann spruce-subalpine fir open forest

Figure 39 Landscape schematic showing the relationship of the Egypt (EG) Ecosites to other Ecosites.



and their relationship to a few other Upper Subalpine and Alpine Ecosites occurring on noncalcareous, medium textured till.

EG - EGYPT 1 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, EG1, occurs on morainal blankets consisting of noncalcareous, medium textured till (Till B) overlying inclined bedrock on valley walls. The soils normally occur in a pattern reflecting degree of eluvial (Ae) horizon development. Eluviated Dystric Brunisols are dominant and Orthic Dystric Brunisols subdominant. Vegetation cover is dominated by the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21), and Engelmann spruce-subalpine fir/heather (O10) v.t.s. C15 and O10 are most abundant but some EG1 tracts are dominated by C21 or C21 plus O10.

Geomorphology

The EG1 Ecosite is typified by morainal blankets overlying inclined bedrock. These moraines consist of noncalcareous, medium textured till (Till B). Surface veneers of altered, medium textured eolian material (Eolian material B) occur extensively on EG1 tracts of western Banff and southwestern Jasper, sporadically elsewhere. Colluvium derived from till and fractured bedrock is found occasionally on the steepest portions of the landscape. A medium textured variant of noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A), derived from slates and shales, may occur occasionally on lower valley wall slopes.

Topographically, EG1 displays long, linear slopes consisting of till mantling the inclined bedrock that forms valley walls. Slopes commonly range from 15 to 70%. Occasionally, linear slopes dissected by gullies occur but much less frequently than on the Peyto Lake 1 (PL1) and Larch Valley 3 (LV3) Ecosites occurring on linear slopes of calcareous, medium textured till (Till C) and noncalcareous, coarse textured till (Till A) respectively. Patches of colluvial blankets and veneers occur occasionally on the steepest terrain, especially below bedrock escarpments. Tracts of EG1 situated along valley floors, at valley confluences, on valley shoulders, in cirque basins and cols, and on failed slopes often display morainal landforms with irregular surfaces and complex topography (5-45% slopes). These landforms include morainal blankets and veneers overlying ridged and hummocky bedrock and the relatively deep till of hummocky moraines. Morainal veneers also occur on linear, inclined slopes and are dominant on tracts mapped as EG1X. Bedrock outcrops occur occasionally but are particularly common on EG1+R tracts.

Soils

The soils of the EG1 Ecosite are distributed in a pattern that reflects degree of eluvial (Ae) horizon develoment. Eluviated Dystric Brunisols are dominant and Orthic Dystric Brunisols subdominant. These well to moderately well drained soils have B horizons that range from comparatively well developed Bm and Bf horizons, associated with altered, medium textured eolian material (Eolian material B) above the parent material disconformity, to moderately developed Bm horizons in the till. Genetically related Orthic Humo-Ferric Podzols with >10 cm of Bf horizon above the parent material disconformity are important accessory soils. These are most abundant on EG1 tracts with extensive Eolian material B veneers. Soils with Bhf and podzolic Bhf horizons occur in minor amounts. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly developed in the absence of Eolian material B. In some localities, recent surface disturbances such as wind throw of trees, avalanching, sheet erosion, and soil creep have inhibited or destroyed Ae horizon development. Many of the EG1 Ecosite soils have, in lower sola and upper C horizons, clay films that are thought to be formed by pressure (e.g. freeze-thaw) rather than clay illuviation. Small amounts of wet soils occur in seeps of depressional localities and Regosolic soils on steep, colluviating portions of the landscape. Lithic soil phases occur sporadically on EG1 but dominate on EG1X tracts.

A pedon illustrating Orthic Dystric Brunisols of EG1 is described in Table 171. Although located within the area of extensive Eolian material B veneers, erosion on this site has removed most of the eolian material. Soil materials on EG1 are generally deeper than this lithic phase pedon. Clay film development as in the lower solum of this pedon is common in soils developed in noncalcareous, medium textured till.

Vegetation

The EG1 Ecosite is dominated by the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21), and Engelmann spruce-subalpine fir/heather (O10) v.t.s, with C15 and O10 being most abundant. The C15 v.t. is most abundant above the boundary between Lower and Upper Subalpine. The O10 v.t. occurs above C15 and is most extensive on northerly aspects. The C21 v.t. replaces C15 throughout northern Jasper (north of the range of *Vaccinium scoparium*) and on many EG1 tracts near the Continental Divide. The accessory v.t., Engelmann spruce-subalpine fir/heather/feathermoss (C34), often occurs at

Table 171 Pedon (Alberta 1976 No. 98) description of an Orthic Dystric Brunisol of the EG1 Ecosite.

LOCATION: MILITARY GRID REF. 11 UNE 7750 6440; NTS MAP AREA 820 4W.

CLIMATE: 2040 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 1 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VTN=C18=.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), MORAINAL (Y1LL); PARENT MATERIAL 2: FRACTURED WEATHERING, FRAGMENTAL (STONES, COBBLES AND GRAVEL), RESIDUAL; DEPTH TO BEDROCK IS 0.9 M; LANDFORM CLASSIFICATION: MORAINAL, FAILING, VENEER; SLOPE: 35% SIMPLE SLOPE OF CLASS 7 (31-45%), FACING WEST, SITE AT UPPER SLOPE POSITION, MODERATELY MOUNDED MICROTOPOGRAPHY,200 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY; PRESENT LAND USE: OUTDOOR RECREATION.

SPECIAL NOTES: SSN=BM6121=APH=783-867=RLU=15=MLU=82=PCF=55L,2ACB(2-5)=2C HORIZON IS FRACTURED BEDROCK,ANGULAR COBBLE SIZE FRAGMENT S=STONES IN PROFILE WEATHERED TO SMALLER FRAGMENTS=AE WEAK,FROZEN,NOT SAMPLED=LFH=HV/RI-F=

LF: 3 TO 0 CM, RANGE 1 TO 5 CM; ABUNDANT, FINE AND MEDIUM ROOTS; WAVY AND BROKEN, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 1 CM, RANGE 0 TO 5 CM; MATRIX MOIST 10YR 6/3; GRAVELLY LOAM; PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; FEW, VERY FINE PORES; ANGULAR COBBLY AND SLATY COARSE FRAGMENTS; CLEAR HORIZON BOUNDARY.

BM1: 1 TO 21 CM, RANGE 17 TO 27 CM; EXPED MOIST 7.5YR 5/6; GRAVELLY LOAM AND LOAM; WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; MANY, VERY FINE PORES; ANGULAR COBBLY AND SLATY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

BM2: 21 TO 58 CM, RANGE 25 TO 55 CM; EXPED MOIST 7.5YR 5/4; GRAVELLY SILT LOAM; MODERATE, FINE, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; FEW, FINE ROOTS; MANY, VERY FINE PORES; FEW, MODERATELY THICK CLAY FILMS ON PED FACES-UNSPECIFIED; ANGULAR COBBLY AND SLATY COARSE FRAGMENTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

BC: 58 TO 80 CM, RANGE 18 TO 28 CM; EXPED MOIST 10YR 5/4; GRAVELLY LOAM; MODERATE, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; FEW, FINE ROOTS; MANY, FINE PORES; COMMON, MODERATELY THICK CLAY FILMS ON PED FACES-UNSPECIFIED; ANGULAR COBBLY AND SLATY COARSE FRAGMENTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

2C: 80 TO 90 CM; ANGULAR COBBLY COARSE FRAGMENTS.

R: 90 CM

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.4	38.90						
AE								
BM1	4.8	0.70	11.2		1.3	0.5	-.1	0.1
BM2	4.1	0.40	8.4		0.7	0.4	0.0	0.1
BC	4.7		4.5		1.2	1.3	-.1	0.1
2C								
R								

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM1	0.3		0.1	
BM2	0.2		-.1	
BC				
2C				
R				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	% OF SAMPLE TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE														
BM1										32		49	19	4
BM2										31		52	17	4
BC										38		44	16	2
2C														
R														

higher elevations than C15 or C21 and below O10. Notable v.t.s in minor amounts are subalpine larch-subalpine fir/grouseberry-everlasting (C23) in southern Banff; Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) and Engelmann spruce/hairy wild rye (C33) on southerly aspects, and Engelmann spruce-subalpine fir/rock willow/white mountain heather (C24) on northerly aspects on EG1 tracts associated with Mesozoic strata in eastern Banff and Jasper. Various moist to wet Upper Subalpine v.t.s occur on seeps in depressional localities. Snow avalanche v.t.s such as subalpine fir-willow (S2) occur on avalanched portions of the landscape. Fire affected vegetation in which spruce is regenerating occurs in some areas, e.g. between the Panther and Red Deer River valleys east of the Bare Mountains in Banff. Lodgepole pine/buffaloberry/ grouseberry (C18) sometimes occurs in or adjacent to burned areas.

A stand illustrating the C15 v.t. of EG1 is described in Table 172. This stand is located about 100 m from the pedon sample site described above (Table 171).

Table 172 Stand (AW6092) illustrating the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. of the EG1 Ecosite.

TREE LAYER	
Abies lasiocarpa	06
Picea engelmannii	41
TALL SHRUB LAYER	
Abies lasiocarpa	04
Picea engelmannii	01
SHRUB LAYER	
Abies lasiocarpa	28
Ledum glandulosum	.5
Menziesia glabella	02
Picea engelmannii	.5
HERB-DWARF SHRUB LAYER	
Arnica cordifolia	01
Cornus canadensis	.5
Listera cordata	.5
Vaccinium myrtillus	05
Vaccinium scoparium	24
BRYOID LAYER	
Barbilophozia hatcheri	20
Cladonia spp.	.5
Dicranum spp.	17
Peltigera aphthosa	01

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

The EG1 Ecosite is the most extensive of the Egypt Ecosites. In terms of physiographic position, landform surface expression, and vegetation, EG1 resembles the Peyto Lake 1 (PL1) and Larch Valley 3 (LV3) Ecosites. However, PL1 differs because it occurs on morainal landforms consisting of calcareous, medium textured till (Till C); LV3 because it occurs on noncalcareous, coarse textured till (Till A). Also, PL1 is dominated by Eutric Brunisols and LV3 is characterized by Dystric Brunisols with thicker sola and Ae horizons than EG1 soils. The EG1 Ecosite is differentiated from other Egypt Ecosites by vegetation differences and amount of wet, seepage affected landscape as outlined in Table 170. The Cavell 2 (CA2) Ecosite is the Lower Subalpine counterpart of EG1.

EG2 - EGYPT 2 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, EG2, occurs on morainal blankets consisting of noncalcareous, medium textured till (Till B) overlying inclined, hummocky, and ridged bedrock. Veneers of altered, medium textured eolian material (Eolian material B) occur extensively and significantly affect soil development. Consequently, EG2 exhibits a soil pattern in which Eluviated Dystric Brunisols are dominant and Orthic Humo-Ferric Podzols are subdominant. Vegetation is dominated by the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. The EG2 Ecosite is the least extensive of the Egypt Ecosites and is found only in Banff south of a line joining Hector Lake, Pipestone Pass, and the Panther River.

Geomorphology

The EG2 Ecosite is typified by morainal blankets overlying inclined, hummocky, or ridged bedrock. These moraines consist of noncalcareous, medium textured till (Till B). The low lime phase occurs rarely. Veneers of altered, medium textured eolian material (Eolian material B) occur extensively. Colluvium derived from till or fractured bedrock occurs rarely.

Topographically, EG2 displays linear, inclined slopes on valley walls or hummocky and ridged surfaces on valley shoulders (Plate 105), cirque basins, and cols. These surface expressions usually reflect underlying bedrock surfaces. Slopes commonly range from 5 to 45%. Morainal veneers and bedrock outcrops occur occasionally. On EG2X tracts morainal veneers dominate and bedrock escarpments are more common than normal for EG2. Deep till deposits, usually with a hummocky surface form, occur occasionally on cirque floors and on failed slopes.

Soils

Eluviated Dystric Brunisols are the dominant soils of the EG2 Ecosite, Orthic Humo-Ferric Podzols the subdominant soils. These well to moderately well drained soils reflect the presence of nearly continuous veneers of altered, medium textured eolian material (Eolian material B) in that they have comparatively well developed Bm, Bf, or podzolic Bf horizons above the parent material disconformity and moderately developed Bm horizons below. The accessory soils, Orthic Dystric Brunisols, occur locally where Eolian material B veneers are absent, where recent surface disturbances have inhibited or destroyed Ae horizon development, or where significant humus incorporation masks the effects of eluviation. Most EG2 soils show, in their upper sola, humic enrichment attributable to the near Alpine environment with larch forest. Consequently, soils with Bhf and podzolic Bhf horizons occur occasionally. Many EG2 soils have, in lower sola and upper C horizons, clay films that are thought to be formed by pressure (e.g. freeze-thaw) rather than illuviation. Wet soils associated with seeps in de-

pressional sites, occur in minor amounts. Lithic soil phases occur sporadically on EG2, being most abundant on hummock and ridge crests. On EG2X tracts, lithic phases are dominant.

A pedon illustrating Orthic Humo-Ferric Podzols of EG2 is described in Table 173. Note the morphological evidence of humus incorporation as shown by the thin Ah horizon at the mineral surface in this pedon.

Table 173 Pedon (Alberta 1977 No. 137) description of an Orthic Humo-ferric Podzol of the EG2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC HUMO-FERRIC PODZOL. SOIL MAP UNIT: NOTATION: EG2.

LOCATION: MILITARY GRID REF. 11 UNG 7280 7040; NTS MAP AREA 82O 4W.

CLIMATE: 2280 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 6 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JD6086*VTN=C23*.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN; PARENT MATERIAL 2: SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), MORAINAL (TILL); LANDFORM CLASSIFICATION: MORAINAL AND UNCONSOLIDATED, BLANKET; SLOPE: 7% COMPLEX SLOPE OF CLASS 6 (6-9%), FACING SOUTHWEST, SITE AT UPPER SLOPE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,20 M LONG; SOIL MOISTURE AND DRAINAGE: MODERATELY WELL DRAINED, SLOWLY PERVIOUS, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY.

SPECIAL NOTES: SSN=GC7055*APN=A22443-51*RLU=15*SSC=ST*PCF=1GR(1-3)3GR,3CB,3ST(U-6)*2C SAMPLED FROM 95 TO 100 CM*TILL QUITE DENSE*LFM=MB/RH*

AH: 0 TO 4 CM, RANGE 2 TO 5 CM; HORIZON MOIST; SILT LOAM; WEAK, FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND MEDIUM ROOTS; GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 4 TO 7 CM, RANGE 1 TO 5 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/3; SILT LOAM; WEAK, MEDIUM, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; FEW, FINE PORES; GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BF: 7 TO 19 CM, RANGE 4 TO 15 CM; HORIZON MOIST; MATRIX MOIST 5YR 4/6; SILT LOAM; MODERATE, VERY FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; MANY, FINE PORES, GRAVELLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2BM: 19 TO 40 CM, RANGE 20 TO 24 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6; LOAM; MODERATE, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; FEW, FINE ROOTS; COMMON, FINE PORES; GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2BC: 40 TO 58 CM, RANGE 14 TO 22 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/4; LOAM; COMMON, FINE, DISTINCT, 7.5YR 5/6 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE PSEUDO; FRIABLE CONSISTENCE; VERY FEW, FINE ROOTS; FEW, FINE PORES; GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2C: 58 TO 99 CM; HORIZON MOIST; INPED MOIST 10YR 5/3.5; LOAM; COMMON, FINE, DISTINCT, 7.5YR 5/6 MOTTLES; STRUCTUPELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, FINE ROOTS; FEW, FINE PORES; FEW, VERY THIN CLAY FILMS ; GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
AH	4.4	15.90	42.1		4.5	1.5	0.2	0.8
AE	4.3	2.50	11.3		0.4	0.3	0.1	0.1
BF	4.8	3.40	21.7		0.5	0.2	0.1	0.1
2BM	4.4	0.70	5.2		0.3	0.1	-.1	-.1
2BC	4.3		4.4		0.4	0.2	-.1	-.1
2C	5.5		4.2		2.4	1.5	0.1	0.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
AH				
AE				
BF	0.5		0.3	
2BM	0.3		0.1	
2BC				
2C				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
AH										18		64	18	3	
AE										31		56	12	2	
BF										28		60	12	0	0.70
2BM										42		39	19		2.00
2BC										43		40	17	0	1.40
2C	99	81	73	61						42		41	17	4	2.10

PHYSICAL DATA

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AH								
AE								
BF								
2BM								
2BC								
2C	22.0	28.0					40	18

Vegetation

The EG2 Ecosite is dominated by the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. An open tree canopy variant of C23 occurs on exposed sites and along the upper elevational boundaries of EG2 tracts. Stunted variants or other avalanche v.t.s such as subalpine fir-willow (S2) occur on avalanched portions of the landscape. Because of map scale limitations, many EG2 tracts have minor amounts of Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21), or Engelmann spruce-subalpine fir/heather (O10) along lower elevational boundaries and patches of heather-everlasting (L5) along upper boundaries. Various moist to wet Upper Subalpine v.t.s, as well as C23 are associated with seeps in depressional localities. A stand representing vegetation of the pedon sample site described above (Table 173) and illustrating the open canopy variant of C23 on EG2 is presented in Table 174 and Plate 106.

Table 174 Stand (JD6086) illustrating the subalpine larch-subalpine fir grouseberry-everlasting (C23) v.t. of the EG2 Ecosite.

TREE LAYER	
Larix lyallii	13
Picea engelmannii	.5
TALL SHRUB LAYER	
Abies lasiocarpa	.5
Larix lyallii	20
Picea engelmannii	.5
SHRUB LAYER	
Abies lasiocarpa	01
Larix lyallii	10
HERB-DWARF SHRUB LAYER	
Anemone occidentalis	01
Antennaria lanata	10
Arnica latifolia	15
Carex nigricans	.5
Carex scirpoidea	02
Cassiope mertensiana	10
Deschampsia atropurpurea	.5
Erigeron peregrinus	.5
Hieracium gracile	.5
Luzula wahlenbergii	05
Pedicularis bracteosa	.5
Phleum alpinum	.5
Phyllodoce empetriformis	07
Phyllodoce glanduliflora	08
Poa cusickii	03
Trisetum spicatum	.5
Vaccinium scoparium	30
Veronica alpina	.5
BRYOID LAYER	
Barbilophozia spp.	03
Brachythecium spp.	03
Cladonia spp.	05
Dicranum spp.	05
Peltigera aphthosa	.5
Polytrichum spp.	02
EPIPHYTES	
Letharia vulpina	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The EG2 Ecosite is the least extensive of the Egypt Ecosites. Its distribution is governed by the geographic range of subalpine larch-subalpine fir/grouseberry-everlasting (C23) on noncalcareous, medium textured till (Till B). In terms of physiographic position, landform surface expression, and vegetation, EG2 resembles the Peyto Lake 3 (PL3) and Larch Valley 3 (LV3) Ecosites. However, PL3 occurs on morainal landforms consisting of calcareous, medium textured till (Till C); LV3 occurs on noncalcareous, coarse textured till (Till A). The PL3 Ecosite exhibits a Eutric Brunisol > Podzol soil pattern. The LV3, like EG2, has a Dystric Brunisol > Podzol soil pattern but its soils are more deeply weathered reflecting coarse parent material. The EG2 Ecosite is differentiated from other Egypt Ecosites by vegetation differences and amount of wet, seepage affected landscape as outlined in Table 170.

EG3 - EGYPT 3 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, EG3, occurs on morainal blankets and veneers consisting of noncalcareous, medium textured till (Till B) overlying hummocky and ridged bedrock that form a compound landscape comprised of about 70% dry (well to moderately well drained, mesic) upland segments and 30% wet (imperfectly to poorly drained, subhygric to subhydric), seepage affected depressions between ridges and hummocks. Upland soils occur in a pattern reflecting degree of eluvial (Ae) horizon development. Eluviated Dystric Brunisols are dominant and Orthic Dystric Brunisols subdominant. Vegetation of upland segments is dominated by the Engelmann spruce-subalpine fir/grouseberry (C15) and Engelmann spruce-subalpine fir/heather (O10) v.t.s except in southern Banff where the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. commonly occurs. A complex set of pedogenically related soils, represented by the Orthic Gleysol, Rego Gleysol, Gleyed Ferro-Humic Podzol, and Gleyed Dystric Brunisol subgroups, occur on wetland segments, usually under the Engelmann spruce-subalpine fir/valerian-fleabane (O9) and fleabane-valerian (H16) v.t.s.

Geomorphology

The EG3 Ecosite is typified by morainal blankets and veneers overlying hummocky and ridged bedrock. These moraines consist of noncalcareous, medium textured till (Till B).

In a few areas, e.g. Redearth Pass in Banff, EG3 tracts include morainal landforms consisting of noncalcareous, coarse textured till (Till A). Surface veneers of altered, medium textured eolian material (Eolian material B) occur extensively on EG3 tracts of western Banff and southwestern Jasper, sporadically elsewhere. Redeposition of this eolian material in thin, altered, fine, stratified fluviolacustrine (Fluviolacustrine material A) veneers has occurred on some depressions. Genetic materials of depressional segments include the till or noncalcareous, coarse, stratified fluvial material (Fluvial material A) existing as level floodplains or veneers and blankets overlying till. These materials may be overlain by the thin fluviolacustrine and eolian veneers. Occasionally, horizontal fens comprised of shallow, moderately decomposed, fen peat may occur on ponded portions of the depressions. Noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A) and colluvium occur rarely on EG3 tracts.

Topographically, EG3 displays a series of subparallel ridges or irregularly distributed knolls (hummocks) separated by gently sloping depressions. The EG3 Ecosite is usually found on valley floors, valley shoulders, cirque basins, and cols. Slopes commonly range from 5 to 45% overall although slopes of <5% are common on depressional segments. Depressions may be level with abrupt borders to upland segments or concave and bowl shaped with subtle margins. Morainal veneers dominate on EG3X tracts. Bedrock outcrops are most common on EG3+R tracts. A few EG3 tracts have linear slopes on lower valley walls, straddling long narrow wetlands along the valley floor. Deep till deposits, usually with a hummocky surface form, occur occasionally on failed slopes and on valley and cirque floors.

Soils

Soils of the EG3 Ecosite are distributed in a pattern governed by drainage conditions. Well to moderately well drained upland segments exhibit a secondary soil pattern reflecting degree of eluvial (Ae) horizon development. Eluviated Dystric Brunisols are dominant and Orthic Dystric Brunisols subdominant in a pattern most often resembling EG1 soil distribution. These soils have B horizons that range from moderately developed Bm horizons at the till surface to the comparatively advanced Bm and Bf horizons associated with altered, medium textured eolian material (Eolian material B). Genetically related Orthic Humo-Ferric Podzols with podzolic Bf horizons above the parent material disconformity are important accessory soils. These are most abundant on EG3 tracts with extensive Eolian material B veneers. Soils with Bhf and podzolic Bhf horizons occur in minor amounts. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly developed in the absence of Eolian material B. In some localities, recent surface disturbances such as wind throw of trees, avalanching, sheet erosion, and soil creep have inhibited or destroyed Ae horizon development. Masking of the eluviation process occurs on soils with humus enriched surface horizons under subalpine larch-subalpine fir/grouseberry-everlasting (C23) or heather-everlasting (L5) vegetation. Consequently, on several EG3 tracts soils of upland segments resemble EG2 soils or EG4 soils. Orthic Sombric Brunisols occur in minor amounts, particularly under L5. Many EG3 upland soils display, in lower sola and upper C horizons, clay films thought to be formed by pressure (e.g. freeze - thaw). Lithic soil phases are associated with morainal veneers and dominate on EG3X tracts. The pedons described in Tables 171, 173, and 175 illustrate soils of the upland segment of EG3.

A variety of pedogenically related and geomorphically modified soils occur on the imperfectly to poorly drained, depressional segments of the EG3 Ecosite. These are best represented by the Orthic Gleysol, Rego Gleysol, Gleyed Ferro-Humic Podzol, and Gleyed Dystric Brunisol Subgroups. Strength of gleying, reflecting degree of movement and aeration of seepage waters, is variable. The presence of eolian or fluviolacustrine veneers promotes the development of iron, aluminum, and humus enriched B and podzolic B horizons (usually Bhf and podzolic Bhf). Recent and continuing fluvial deposition, long periods of saturation, and severe solifluction or cryoturbation retard or destroy pedogenic horizonation (Rego Gleysols). Turbic phases of other soils also occur. Gleyed Eluviated Dystric Brunisols, various gleyed Regosolics, and Humic Gleysols may be found occasionally. Terric Mesisols occur occasionally on ponded sites. The pedons described in Tables 340, 342, and 344 for the Sphinx (SX) Ecosites illustrate soils common to EG3 depressional segments.

Vegetation

Vegetation of the EG3 Ecosite is distributed in a pattern governed by drainage conditions. The upland segments are dominated by the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/heather (O10), and subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t.s. The C15 and O10 v.t.s. are most abundant and resemble EG1 vegetation. Upland segments of several EG3 tracts in southern Banff are dominated by C23, thereby resembling EG2. Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) in northern Jasper and along the Continental Divide, Engelmann spruce-subalpine fir/heather/feathermoss (C34), and at high elevations heather-everlasting (L5) are important accessory v.t.s. Modification by

snow avalanching and fire has occurred in some areas.

A variety of moist to wet Upper Subalpine v.t.s, best represented by Engelmann spruce-subalpine fir/valerian-fleabane (O9) and fleabane-valerian (H16), occur on the seepage affected depressional segments of the EG3 Ecosite. Willow/cinquefoil (S8) is an accessory v.t. and occurs most often on EG3 tracts of eastern Banff and Jasper on till and fluvial materials derived from Mesozoic strata. Occasionally O10 and C23 extend onto depressions from upland localities. Other v.t.s in minor amounts are dwarf birch-shrubby cinquefoil/needlerush (S3), willow/timber oatgrass (S11), Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14), mountain marigold-globeflower (H9), and an Engelmann spruce-subalpine fir/willow/hairy wild rye (O18) variant in recently burned areas.

Discussion

The EG3 Ecosite encompasses a compound landscape pattern consisting of well to moderately well drained upland segments similar to EG1, occasionally to EG2 and EG4, and imperfectly to poorly drained depressional segments similar to the Sphinx (SX) or Num-Ti-Jah 2 (NT2) Ecosites. The proportion of wet depressions on EG3 tracts commonly ranges from 20 to 40%. Map presentation of EG3 tracts at scales larger than 1:50,000 is invalid because these segments would become mappable as separate Ecosites. The EG3 Ecosite most closely resembles the Peyto Lake 5 (PL5) Ecosite. The PL5 Ecosite however, occurs on morainal landforms consisting of calcareous, medium textured till (Till C) and is dominated by Eutric Brunisols on upland segments. The infrequent Upper Subalpine occurrences of a dry > wet pattern on noncalcareous, coarse textured till (Till A) landforms are also mapped as EG3. The Cavell 1 (CA1) Ecosite is the Lower Subalpine counterpart of EG3.

EG4 - EGYPT 4 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, EG4, occurs on morainal blankets and veneers consisting of noncalcareous, medium textured till (Till B) overlying inclined, hummocky, and ridged bedrock. A soil pattern relating to the amount of humus accumulation and presence of altered, medium textured eolian (Eolian material B) veneers characterizes EG4. Orthic and Eluviated Dystric Brunisols are dominant; Orthic Sombric Brunisols and Orthic Ferro-Humic Podzols are subdominant. A pattern of heather-everlasting (L5) interspersed with islands of Engelmann spruce-subalpine fir/heather (O10) characterizes the vegetation of this Ecosite. The EG4 Ecosite represents the uppermost part of the Upper Subalpine on noncalcareous, medium textured till and is normally bounded above by Alpine Ecosites and below by Upper Subalpine Ecosites with closed to open forests of Engelmann spruce - subalpine fir or subalpine larch - subalpine fir.

Geomorphology

The EG4 Ecosite is typified by morainal blankets and veneers overlying inclined, hummocky, and ridged bedrock. These moraines consist of noncalcareous, medium textured till (Till B). Surface veneers of altered, medium textured eolian material (Eolian material B) occur extensively on EG4 tracts of western Banff and southwestern Jasper, sporadically elsewhere. Colluvium derived from till or fractured bedrock is found occasionally on the steepest portions of the landscape. Noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A) rarely occurs.

Topographically, EG4 displays linear, inclined slopes on valley walls or hummocky and ridged surfaces on valley shoulders, cirque basins, and cols. These surface expressions usually reflect underlying bedrock surfaces. Slopes commonly range from 5 to 70%. Linear slopes are occasionally gullied. Morainal veneers are common and dominate on EG4X tracts. Bedrock outcrops are most common on EG4+R tracts. Patches of colluvium existing as blankets and veneers occur occasionally on the steepest terrain, particularly below bedrock escarpments. Deep till deposits, usually with a hummocky surface form, occur occasionally on failed slopes and cirque floors.

Soils

A soil pattern in which Orthic and Eluviated Dystric Brunisols are dominant and Orthic Sombric Brunisols and Orthic Ferro-Humic Podzols subdominant characterizes the EG4 Ecosite. In the near Alpine environment organic matter accumulation in the upper sola of these soils is significantly greater than on other Egypt Ecosite soils. Thus, the effects of eluviation are often masked and EG4 soils have varying thicknesses of Ah and Ahe horizons. Where altered, medium textured eolian material (Eolian material B) veneers are present, these soils often have advanced Bhf or podzolic Bhf horizons above and moderately developed Bm horizons below the parent material disconformity. Soils with Bf and podzolic Bf horizons occur occasionally. Some EG4 soils display, in lower sola and upper C horizons, clay films thought to be formed by pressure (e.g. freeze-thaw) rather than illuviation. Turbic soil phases produced by cryoturbation and solifluction are common among EG4 soils, particularly on EG4 tracts of eastern Banff and Jasper. Lithic phases

Table 175 Pedon (Alberta 1978 No. 41) description of an Orthic Dystric Brunisol of the EG4 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: EG4.

LOCATION: MILITARY GRID REF. 11 UNH 4139 2430; NTS MAP AREA 82N 9W.

CLIMATE: 2250 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING AT 50 CM IN OCTOBER.

VEGETATION: VPN=JE0159=VTH=L05=.

SOIL SITE: PARENT MATERIAL 1: FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), UNDIFFERENTIATED, EOLIAN; PARENT MATERIAL 2: COARSE LOAMY AND COARSE SILTY (<16% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.S.S), MORAINAL (TILL); DEPTH TO BEDROCK IS 0.6 M; LANDFORM CLASSIFICATION: MORAINAL, VENEER; SLOPE: 25% SIMPLE SLOPE OF CLASS 6 (16-30%), FACING EAST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,80 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE PRESENT; SLIGHTLY STONY; NONROCKY.

SPECIAL NOTES: SSN=TA8148=APH=783-095=RLU=15=LFH=HV/RI=COARSE FRAGMENTS PRESENT BUT NOT DESCRIBED=

LF: 7 TO 0 CM, RANGE 6 TO 9 CM; MATRIX MOIST 10YR 2/1; ABUNDANT, VERY FINE AND FINE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AHE: 0 TO 8 CM, RANGE 4 TO 10 CM; MATRIX MOIST 10YR 3/2; SILTY CLAY; VERY WEAK, VERY FINE TO FINE, PLATY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BHF: 8 TO 14 CM, RANGE 4 TO 8 CM; MATRIX MOIST 5YR 3/3; SILT LOAM; WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

2BC: 14 TO 53 CM; MATRIX MOIST 10YR 5/3; LOAM; WEAK TO MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE PSEUDO; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; FIRM CONSISTENCE; VERY FEW, VERY FINE ROOTS.

R: 53 CM

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.8	21.10						
AHE	4.8	7.00	37.3		5.5	1.8	0.1	0.2
BHF	4.9	7.00	49.5		6.5	2.2	0.1	0.3
2BC	4.9		5.5		1.7	0.9	-.1	0.1
R								

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AHE	0.8		0.7	
BHF	0.8		0.6	
2BC	0.2		-.1	
R				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 78-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF					1	1	1	3	7	13		50	37	
AHE						1		1	7	9		65	26	
BHF														
2BC	99	91	65	51	8	8	9	16	10	51		38	11	
R														

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	ENGINEERING AASHO CLASS	UNIFIED CLASS
LF													
AHE		48.6	30.4										
BHF													
2BC		13.4	4.9			17.0	20.0		13.0	1.8		24	18
C													

are associated with morainal veneers and dominate on EG4X tracts. Depressional localities with various seepage affected wet soils may constitute up to 20% of EG4 tracts. Regosolic soils occur occasionally on severely soliflucted, cryoturbated, and colluviated sites.

A pedon illustrating Orthic Dystric Brunisols (lithic phase) of EG4 is described in Table 175 and shown in Color Plate 17. Textural characteristics of this pedon's surface horizons suggest that the Eolian material B at this site has been reworked by slowly moving water. Soils of the EG4 Ecosite normally have deeper till and thicker sola than this pedon displays.

Vegetation

The EG4 Ecosite is dominated by a vegetation pattern in which the heather-everlasting (L5) v.t. is more abundant than the Engelmann spruce-subalpine fir/heather (O10) v.t. The O10 v.t. normally exists as discrete patches or islands of trees but includes islands of krummholz on exposed sites or at

the Upper Subalpine - Alpine boundary. Tree islands cover about 50% of the landscape at lowest elevations, 5% at highest elevations. Islands of subalpine larch-subalpine fir/grouseberry-everlasting (C23) often replace O10 on EG4 tracts located in southern Banff. Patches of white mountain heather-mountain avens-snow willow (L4) and mountain avens-snow willow-moss campion (H1) occur occasionally with H1 being restricted to exposed ridge and hummock crests or to severely soliflucted sites on EG4 tracts associated with Mesozoic strata in eastern Banff and Jasper. Seepage affected depressional localities often have moist Upper Subalpine v.t.s such as Engelmann spruce-subalpine fir/valerian-fleabane (09) and fleabane-valerian (H16). Modification by avalanching and fire, although difficult to identify on EG4 vegetation, occurs occasionally. A stand representing vegetation of the pedon sample site described above (Table 175) and illustrating the L5 segment of the EG4 vegetation pattern is described in Table 176.

Table 176 Stand (JE8159) illustrating the heather-everlasting (L5) portion of the v.t. pattern of the EG4 Ecosite.

SHRUB LAYER	
Abies lasiocarpa	01
Picea engelmannii	01
HERB-DWARF SHRUB LAYER	
Anemone occidentalis	.5
Antennaria lanata	02
Cassiope mertensiana	30
Erigeron peregrinus	.5
Pedicularis bracteosa	.5
Phleum alpinum	.5
Phyllodoce glanduliflora	25
Poa spp.	02
Polygonum viviparum	.5
Salix arctica	03
Vaccinium scoparium	02
Valeriana sitchensis	.5
BRYOID LAYER	
Barbilophozia lycopodioides	.5
Bryum spp.	.5
Cetraria islandica	03
Cladonia carneola	.5
Cladonia ecmocyna	02
Cladonia spp.	.5
Dicranum brevifolium	.5
Dicranum scoparium	01
Peltigera aphthosa	.5
Peltigera rufescens	.5
Pohlia nutans	.5
Polytrichum juniperinum	01
Pseudoleskea radicosa	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The EG4 Ecosite represents the Upper Subalpine - Alpine ecotone on noncalcareous, medium textured till (Till B). In terms of physiographic position, landform surface expression and vegetation, EG4 resembles the Peyto Lake 4 (PL4) and Larch Valley 2 (LV2) Ecosites. However, PL4 occurs on morainal landforms consisting of calcareous, medium textured till (Till C); LV2 occurs on noncalcareous, coarse textured till (Till A). The PL4 Ecosite has Eutric and Melanic Brunisols. The LV2 Ecosite, like EG4, has Dystric and Sombric Brunisols but its soils are more deeply weathered, reflecting coarse textured parent material. The EG4 Ecosite is differentiated from other Egypt Ecosites by vegetation differences and amount of wet, seepage affected landscape as outlined in Table 170. Jonas 1 (JN1) is the Alpine counterpart of EG4.

EN - ENDLESS CHAIN ECOSECTION

The Endless Chain (EN) Ecosection encompasses steep, usually linear, colluvial landforms comprised of noncalcareous, coarse textured colluvium (Colluvium A) in the Upper Subalpine portion of the Subalpine Ecoregion of Banff and Jasper. It occurs principally in the Main Ranges on or below steep, rocky, valley walls in areas that are geologically dominated by Cambrian Gog Group quartzites.

Deeply weathered Dystric Brunisols are dominant and reflect, in their development, the coarse textured, acidic parent material. Minor morphological irregularities are attributable to past and present colluvial activity. Regosolic soils are, in some cases, subdominant and correlated with localities of most active colluviation. Three Endless Chain Ecosites are differentiated on vegetation differences (Table 177) that reflect type and degree of colluvial activity. Vegetation on EN includes Engelmann spruce - subalpine fir closed and open forest, mixed coniferous open forest, and an avalanche complex of v.t.s. Fig. 40 shows, schematically, the physiographic positions of the EN1, EN2 and EN3 Ecosites.

EN1 - ENDLESS CHAIN 1 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, EN1, encompasses blankets and veneers consisting of noncalcareous, coarse textured colluvium (Colluvium A) overlying inclined bedrock on steep valley walls. The deeply weathered EN1 soils, dominated by Eluviated Dystric Brunisols, suggest by their development that colluviation is slow enough that it is not preventing profile development. Likewise, vegetation is well developed and is dominated by the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21), and Engelmann spruce-subalpine fir/heather (O10) v.t.s. The C15 v.t. is most abundant.

Figure 40 Landscape schematic showing the relationship of the Endless Chain Ecosites (EN1, EN2, and EN3) to other Ecosites.

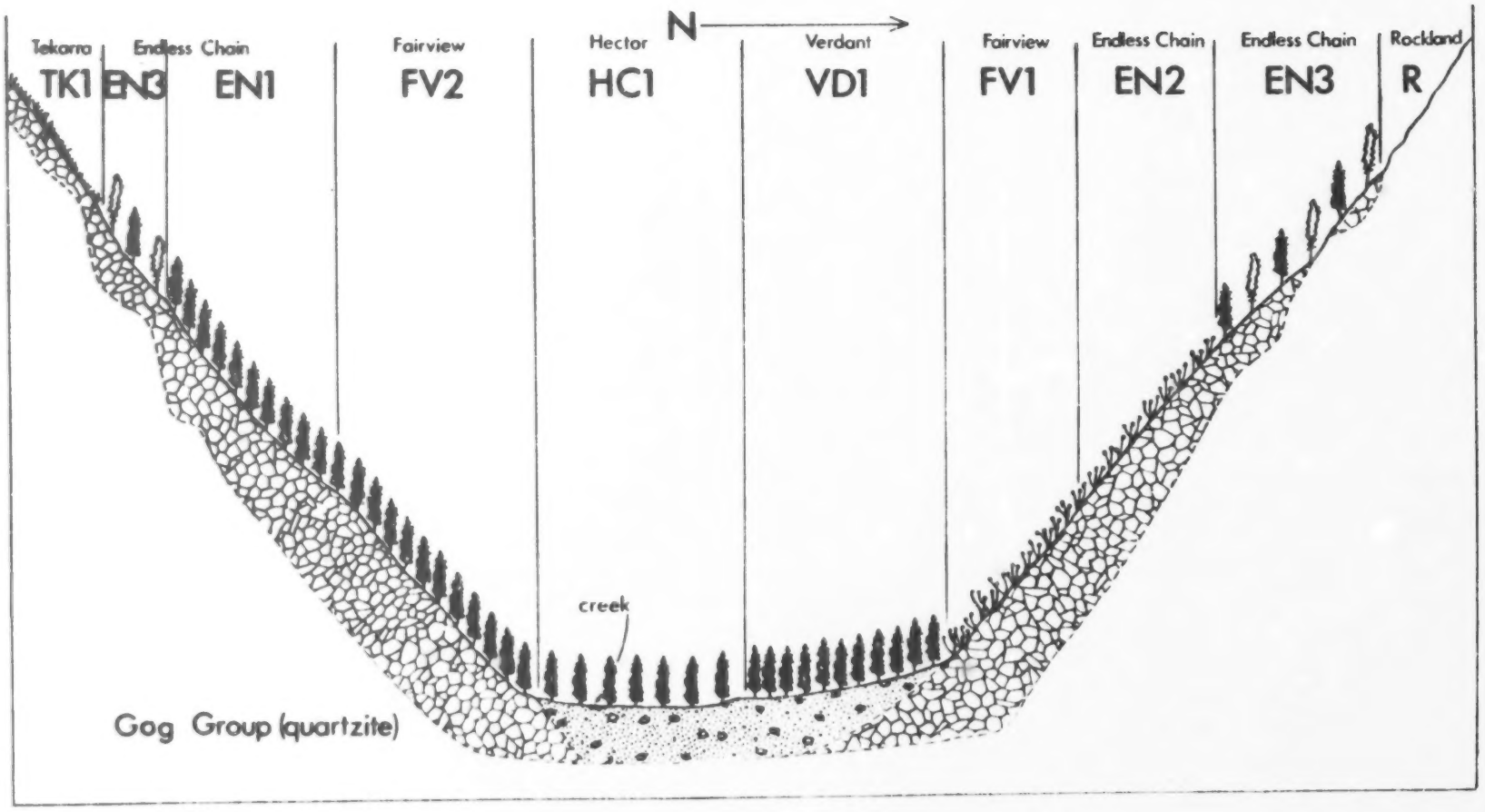


Table 177 General features of the Endless Chain (EN) Ecosites.

Ecosite	Landform	Soils	Vegetation
EN1	Colluvium A; blanket, veneer	Dystric Brunisol	Engelmann spruce-subalpine fir closed and open forests
EN2	Colluvium A; blanket, veneer, , apron	Dystric Brunisol > Regosol	Avalanche Complex 2 > mixed coniferous open forest, Engelmann spruce-subalpine fir open forest
EN3	Colluvium A; blanket, veneer > bedrock; inclined	Dystric Brunisol > Regosol	mixed coniferous open forest > Engelmann spruce-subalpine fir open forest

Geomorphology

The EN1 Ecosite occurs on colluvial blankets and veneers consisting of noncalcareous, coarse textured colluvium (Colluvium A) overlying inclined bedrock on steep valley walls. Underlying bedrock is predominantly Gog Group quartzites although some EN1A tracts, such as one north of Cascade Mountain in Banff, contain material derived from quartz sandstone of the Rocky Mountain Group. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically and are most abundant on EN1 tracts of western Banff and southwestern Jasper. Erosional and colluvial processes have removed or incorporated most evidence of the wind blown accumulation. Till occasionally underlies colluvial material along lower, more gentle slopes of EN1 tracts. Thin fluvial deposits, generally a weakly sorted variant of noncalcareous, coarse, stratified fluvial material (Fluvial material A), occasionally are interbedded with colluvium on avalanched portions of EN1A tracts.

Topographically, EN1 displays long, linear slopes commonly ranging from 45 to 90%. Tracts of EN1 with complex topography exhibit linear colluvial slopes whose continuity is broken by one or more exceptionally steep rock escarpments. Surface form is controlled by deposition and underlying bedrock. The colluvial material is generally shallowest (veneers) at the tops of slopes and deepens downslope. Colluvial aprons occur occasionally along slope bases at major slope breaks. Colluvial veneers dominate EN1X tracts.

Soils

The soil development of the EN1 Ecosite reflects acid, rapidly pervious, parent material and stable geomorphic conditions. Eluviated Dystric Brunisols are dominant. These rapidly to well drained soils have strongly developed B horizons, thick sola, and thick, well developed, eluvial (Ae) horizons. Orthic Dystric Brunisols and Orthic Humo-Ferric Podzols are important accessory soils. Orthic Dystric Brunisols occur on localities where surface disturbances such as avalanching are sufficient to inhibit or destroy Ae horizon development. Orthic Humo-Ferric Podzols are associated with the altered, medium textured eolian (Eolian material B) veneers and have podzolic Bf horizons above the parent material disconformity. Orthic Regosols occur in minor amounts on rubbly and actively colluviating sites.

A pedon illustrating Eluviated Dystric Brunisols of EN1 is described in Table 178 and shown in Color Plate 18. The upper solum is developed in a mixture of Eolian material B and Colluvial material A. The PH characteristics through the profile suggest that these parent materials of the upper solum are young or contained some calcareous particles. The IIBC1 horizon contains clay films, a feature not common to EN1 soils.

Vegetation

Vegetation cover of the EN1 Ecosite indicates stable geomorphic conditions. The Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21), and Engelmann spruce-subalpine fir/heather (O10) v.t.s are dominant. Within the elevational range of EN1, C15 is most abundant and extensive at low elevations and on southerly aspects. A few EN1 tracts are dominated by C21 and O10. The C21 v.t. replaces C15 throughout northern Jasper (north of the range of *Vaccinium scoparium*) and on some tracts near the Continental Divide. The O10 v.t. occurs above C15 and C21 and is most extensive on northerly aspects. Subalpine larch—subalpine fir/grouseberry—everlasting (C23) is an important accessory v.t. occurring on several EN1 tracts in southwestern Banff south of Hector Lake and Pipestone Pass. Many tracts mapped as EN1A have up to 50% of their area avalanched and contain avalanche v.t.s. such as subalpine fir-willow (S2) and juniper-willow (L2). A plot representing vegetation of the pedon sample site described above (Table 178) and illustrating C15 on

Table 178 Pedon (Alberta 1978 No. 80) description of an Eluviated Dystric Brunisol of the EN1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: EN1.

LOCATION: MILITARY GRID REF. 11 UNH 3900 3910; NTS MAP AREA 82H 16W.

CLIMATE: 2210 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 5 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VPN=JC8198 VTH=C18.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EOLIAN; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND SKELETAL (>35% OF PARTICLES 2-25 CM), MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), COLLUVIAL, QUARTZITE; DEPTH TO BEDROCK IS 1.1 M; LANDFORM CLASSIFICATION: COLLUVIAL, VENEER; SLOPE: 55% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING SOUTHEAST, SITE AT MIDDLE POSITION, SLIGHTLY ROUNDED MICROTOPOGRAPHY,200 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; VERY STONY; MODERATELY ROCKY.

SPECIAL NOTES: SSN=MT0159=AFN=818-287=RLU=18=PCP=2ASR,2ACB,1ST(2-3)4ASR,1GR,2ACB,1ST(4-6)=YELLOW MYCELIA IN HORIZONS AE,BM, 2BM=LFH=CV/BI=

LF: 4 TO 0 CM, RANGE 3 TO 5 CM; MATRIX MOIST 10YR 2/1; WAVY, CLEAR HORIZON BOUNDARY.

AE: 0 TO 11 CM, RANGE 7 TO 14 CM; MATRIX MOIST 10YR 7/3; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE AND MEDIUM AND COARSE ROOTS; 20% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

BM: 11 TO 23 CM, RANGE 10 TO 15 CM; MATRIX MOIST 7.5YR 5/6; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE AND MEDIUM AND COARSE ROOTS; 20% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

2BM: 23 TO 43 CM, RANGE 17 TO 25 CM; MATRIX MOIST 10YR 6/5; GRAVELLY SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; 50% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY; VERY STRONGLY ACID 4.6-5.0 FIELD PH.

2BC1: 43 TO 90 CM, RANGE 45 TO 55 CM; MATRIX MOIST 10YR 6/4; GRAVELLY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE; FIRM CONSISTENCE; FEW, MICRO AND VERY FINE AND FINE ROOTS; VERY FEW, VERY FINE PORES; FEW, VERY THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; 50% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2BC2: 90 TO 105 CM; MATRIX MOIST ; GRAVELLY SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; 50% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

R: 105 CM

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	5.6	37.30						
AE	4.9	2.40	13.8		7.7	1.6	0.1	0.3
BM	5.3	2.70	15.5		6.2	1.0	0.2	0.6
2BM	4.9	0.70	6.9		4.4	1.4	<.1	0.2
2BC1	5.8		6.9		5.4	1.8	<.1	0.2
2BC2	5.6		23.8		4.4	2.8	0.1	0.1
R								

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	0.1		0.1	
2BM	0.1		<.1	
2BC1				
2BC2				
R				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE					4	6	7	9	8	34		54	12	
BM					2	4	5	6	9	26		67	7	
2BM					9	11	11	14	9	52		41	7	
2BC1					7	11	11	14	7	50		36	14	
2BC2		99	58	38	6	14	15	13	16	7	65		29	6
R														

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE		19.8	7.8										
BM													
2BM													
2BC1		13.4	6.4										
2BC2		10.4	5.6									11	01
R													

EN1 is presented in Table 179 and Plate 107.

Table 179 Stand (JC8095) illustrating the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. of the EN1 Ecosite.

TREE LAYER	
Picea engelmannii	30
HERB-DWARF SHRUB LAYER	
Achillea millefolium	.5
Arnica cordifolia	.5
Carex concinna	.5
Elymus innovatus	.5
Empetrum nigrum	08
Juniperus communis	02
Linnaea borealis	05
Vaccinium scoparium	35
BRYOID LAYER	
Cladonia lepidota	.5
Cladonia pyxidata	.5
Dicranum fuscescens	08
Drepanocladus uncinatus	01
Eurhynchium pulchellum	01
Psoroma hypnorum	.5
Tortula norvegica	.5
Tortula ruralis	.5
EPIPHYTES	
Cetraria pinastri	.5
Parmelia exasperatula	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The EN1 Ecosite is the least extensive of the Endless Chain Ecosites and is of limited extent overall. In terms of landform surface expression, physiographic position, and vegetation cover, EN1 resembles the Wildflower 1 (WF1) and Whitehorn 2 (WH2) Ecosites. However, in contrast to the Colluvium A characterizing EN1, WF1 occurs on landforms consisting of calcareous, medium textured colluvium (Colluvium C), and WH2 occurs on noncalcareous, medium textured colluvium (Colluvium B). Also, WF1 has neutral to alkaline Eutric Brunisols and a significant amount of Regosolic soils. The WH2 Ecosite, like EN1, has Dystric Brunisols but in the former both sola and Ae horizons are thinner. The EN2 and EN3 Ecosites are differentiated from EN1 primarily by vegetation differences (Table 177) that reflect varying type and degree of colluvial activity. The Fairview 2 (FV2) Ecosite, where it occurs on landforms of noncalcareous, coarse textured colluvium (Colluvium A), is the Lower Subalpine counterpart to EN1.

EN2 - ENDLESS CHAIN 2 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, EN2, encompasses avalanched colluvial landforms comprised of noncalcareous, coarse textured colluvium (Colluvium A). These exist as blankets and veneers overlying inclined bedrock on steep valley walls and as aprons along slope bases at major slope breaks. Snow avalanching is characteristic and governs the distribution of vegetation and, to a lesser extent, soils. Perla and Martinelli (1975) discuss much of the scope of avalanching. A soil pattern in which Eluviated Dystric Brunisols are dominant and Orthic Dystric Brunisols and Orthic Regosols are subdominant typifies the soil component of EN2. Avalanched segments dominate and are characterized by a heterogeneous complex of v.t.s that include subalpine fir-willow (S2), willow-dwarf birch-shrubby cinquefoil (S10), juniper-willow (L2), hairy wild rye-wild strawberry-fireweed (H5), fleabane-valerian (H16) plus intergrades, collectively called Avalanche Complex 2. Forested strips and patches between avalanche tracks and fringing runout zones are subdominant and best represented by the Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) and Engelmann spruce-subalpine fir/heather (O10) v.t.s.

Geomorphology

The EN2 Ecosite occurs on blankets, veneers, and aprons comprised of noncalcareous, coarse textured colluvium (Colluvium A). Source bedrock is predominantly Gog Group quartzite, but quartz sandstone occurs occasionally. For example, one EN2 tract near Pipestone Pass warden cabin in Banff contains material derived from the Mount Wilson Formation. More than 50% of EN2 is modified by snow avalanching. Avalanching of such areal extent usually occurs as coalescing unconfined avalanche paths, or as runout zones below the length of a cliff. Gully-like channeled avalanche tracks (chutes) are common as well.

Genetic material stability within EN2 tracts is greatest on portions unaffected by avalanching, but the unconfined avalanche tracks are almost as stable. Together these components make up a majority of the area of most EN2 tracts. Instability is of two kinds. Erosion of unconsolidated material occurs, though infrequently, on steep avalanche starting zones and on walls of channeled tracks. It is usually evidenced by sparsely vegetated patches. Deposition is a more common process and frequently includes material derived from bedrock exposures high on, or above the EN2 tract. Talus also occurs, with its location and extent controlled by the cliffs above. Material carried by avalanching is distributed downslope to gentler runout zones. Colluvial material is modified by intermittent streams below couloirs and on avalanche runout zones. Fluvial deposits, occurring as thin veneers and layers interbedded with colluvium, are most abundant below channeled tracks and couloirs.

This fluvial material is a weakly sorted variant of noncalcareous, coarse, stratified fluvial material (Fluvial material A) and, like the colluvium, is coarse textured with a high content of angular coarse fragments. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically on the subdominant unavalanched segments of the landscape. Rubble without fine earth material for soil development is common on some EN2 tracts, particularly those occurring as aprons below steep rock walls (e.g. colluvial aprons along the bases of Mt. Mahood and Mt. Moren in the upper Miette River valley in Jasper).

Topographically, EN2 displays long, linear, inclined slopes commonly ranging from 45 to 90%. Slopes <45% occur on the lower slopes and toes of colluvial aprons. Surface form is controlled by deposition and underlying bedrock. The colluvial material is generally shallowest (veneers) at the tops of slopes and deepens downslope to form aprons along slope bases at major slope breaks. Colluvial aprons also occur below rock walls. Shallow channels and accompanying levees, constructed by intermittent streams, are often associated with a wide range of gullying on avalanche tracks. Colluvial veneers dominate those tracts mapped as EN2X. Tracts with failed slopes, mapped as EN2F, occur occasionally. These include slopes characterized by failure of the unconsolidated material and partial failure of underlying bedrock.

Soils

Soil distribution and development on the EN2 Ecosite is related to genetic material stability as influenced by avalanching and supplementary processes. A soil pattern, in which Eluviated Dystric Brunisols are dominant and Orthic Dystric Brunisols and Orthic Regosols are subdominant, characterizes EN2. Eluviated Dystric Brunisols occur where geomorphic activity is least frequent or intense, especially on the forested segments or avalanched segments without cliffs above. Orthic Dystric Brunisols occupy localities where surface modification is weak but eluvial (Ae) horizon development is retarded or has been destroyed. On localities where erosion or deposition is frequent and intense, Orthic Regosols are abundant.

Soils of the EN2 Ecosite are rapidly to well drained and reflect, in their development, the acidic, rapidly pervious, parent material. The Brunisolic soils have thick sola and strongly developed B horizons. Thick, well developed, eluvial (Ae) horizons occur in stable positions. Thin Ah horizons are common under deciduous vegetation. Orthic Sombric Brunisols and Cumulic Regosols occur in minor amounts on avalanched segments. Orthic Humo-Ferric Podzols occur occasionally on forested segments and are associated with the altered, medium textured eolian (Eolian material B) veneers. A pedon illustrating Eluviated Dystric Brunisols of EN2 is described in Table 180 and shown in Color Plate 19.

Vegetation

Vegetation distribution on the EN2 Ecosite is governed by the frequency and intensity of avalanching. Avalanched segments dominate and are characterized by a heterogeneous complex of avalanche v.t.s including subalpine fir-willow (S2), willow-dwarf birch-shrubby cinquefoil (S10), juniper-willow (L2), hairy wild rye-wild strawberry-fireweed (H5), fleabane-valerian (H16) plus intergrades, collectively termed Avalanche Complex 2. The S2 and L2 v.t.s are most abundant and extensive on EN2 but the other avalanche v.t.s plus intergrades occur occasionally. Heather-everlasting (L5) occurs in minor amounts. A plot representing vegetation of the pedon sample site described in Table 180 and illustrating S2 on EN2 avalanched segments is presented in Table 181 and Plate 108.

Table 181 Stand (LC9171) illustrating the subalpine fir-willow (S2) v.t. of the EN2 Ecosite.

SHRUB LAYER	
Abies lasiocarpa	35
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	02
Achillea millefolium	.5
Arctostaphylos uva-ursi	08
Artemisia norvegica	01
Calamagrostis inexpansa	01
Campanula rotundifolia	.5
Dryas octopetala	02
Empetrum nigrum	22
Epilobium angustifolium	.5
Juniperus communis	03
Linnaea borealis	.5
Phyllodoce spp.	03
Picea engelmannii	.5
Saxifraga bronchialis	06
Selaginella rupestris	.5
Vaccinium scoparium	.5
Vaccinium vitis-idaea	02
BRYOID LAYER	
Barbilophozia hatcheri	.5
Barbilophozia lycopodioides	01
Brachythecium curtum	.5
Ceratodon purpureus	02
Cladonia ecmocyna	03
Cladonia fimbriata	.5
Cladonia pleurota	01
Dicranum brevifolium	05
Dicranum scoparium	05
Ditrichum flexicaule	.5
Drepanocladus uncinatus	02
Lecidea granulosa	.5
Peltigera rufescens	01
Pohlia nutans	02
Rhizocarpon geographicum	.5
Thuidium abietinum	03
Tortella tortuosa	.5
EPIPHYTES	
Letharia vulpina	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Table 180 Pedon (Alberta 1979 No. 71) description of an Eluviated Dystric Brunisol of the EN2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: EN2.

LOCATION: MILITARY GRID REF. 11 UNJ 2250 4720; NTS MAP AREA 030 16=.

CLIMATE: 2130 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 5 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPH=LC9171=VTH=32=.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, SANDY AND COARSE LOAMY AND COARSE SILTY (<16% CLAY) AND SKELETAL (>35% OF PARTICLES 2-25 CM), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), FLUVIAL, QUARTZITE; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<16% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), COLLUVIAL, SLATE AND QUARTZITE; LANDFORM CLASSIFICATION: ACTIVE COLLUVIAL, AVALANCHED, APRON; SLOPE: 55% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING SOUTH, SITE AT MIDDLE POSITION, LEVEL MICROTOPOGRAPHY,500 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; EXCEEDINGLY STONY; NONROCKY.

SPECIAL NOTES: SSN=BW9120=APN=A23015-067=RLU=13=SSC=FDX=PCF=2ASR(1)4AB,2AC,T(2-6)3AB,4AC,3ST(5-6)=LFH=EV/CA-A=SLIGHT STRATIF IN FV=PH=5.5 AT 62CM=DATE=SEPT.6,1979

AH: 0 TO 3 CM, RANGE 1 TO 4 CM; MATRIX MOIST 10YR 2/1; ABUNDANT, VERY FINE ROOTS; 10% ANGULAR GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE1: 3 TO 16 CM, RANGE 11 TO 15 CM; MATRIX DRY 10YR 5/4; GRAVELLY COARSE SANDY LOAM; VERY WEAK, FINE, PLATY STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; SOFT CONSISTENCE; ABUNDANT, FINE ROOTS; 40% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE2: 16 TO 42 CM, RANGE 28 TO 28 CM; MATRIX DRY 10YR 6/6; GRAVELLY COARSE SANDY LOAM; VERY WEAK, FINE, PLATY STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; SOFT CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; 40% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

AB1: 42 TO 45 CM, RANGE 3 TO 8 CM; MATRIX DRY 10YR 6/3; GRAVELLY SANDY LOAM; WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; SOFT CONSISTENCE; ABUNDANT, VERY FINE AND FINE ROOTS; 40% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

2AB: 45 TO 62 CM, RANGE 13 TO 18 CM; MATRIX DRY 10YR 5/4, SANDY LOAM; WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; 60% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY; STRONGLY ACID 5.1-5.5 FIELD PH.

2BM: 62 TO 123 CM; MATRIX MOIST 7.5YR 5/6; LOAMY COARSE SAND; VERY WEAK, VERY FINE, SUBANSULAR BLOCKY STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; LOOSE CONSISTENCE; FEW, VERY FINE ROOTS; 60% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; STRONGLY ACID 5.1-5.5 FIELD PH.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
AH	4.9	13.10						
AE1	5.0	2.00	8.2		1.4	0.5	0.1	0.1
AE2	5.4	0.60	3.6		1.3	0.2	-.1	0.1
AB1	4.9	0.70	4.9		0.9	0.2	-.1	0.1
2AB	5.3	0.80	4.5		0.5	0.2	-.1	0.1
2BM	5.5	0.60	4.5		0.9	0.2	-.1	0.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
AH				
AE1				
AE2				
AB1				
2AB				
2BM	0.1		0.1	

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
AH														
AE1					12	16	18	19	8	73		23	4	
AE2					17	19	17	17	6	76		16	8	
AB1					9	14	17	19	7	66		25	9	
2AB					6	15	18	19	8	66		23	11	
2BM	99	64	43	35	19	16	15	16	7	73		19	8	

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AH								
AE1								
AE2								
AB1								
2AB								
2BM							11	02

Unavalanched or infrequently avalanched segments may constitute up to 50% of EN2 tracts and occur as forested strips between avalanche tracks, and as patches along lower slopes fringing avalanche runout zones. The Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) and Engelmann spruce-subalpine fir/heather (O10) v.t.s are most abundant on these segments. The O4 v.t. occurs on dry southerly aspects; O10 favors more moist conditions. Engelmann spruce-subalpine fir/grouseberry (C15) occurs as an accessory v.t. and is common at low elevations. Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) also occurs occasionally and replaces C15 in northern Jasper, north of the range of *Vaccinium scoparium*. Subalpine larch-subalpine fir/grouseberry-everlasting (C23) occurs occasionally in southern Banff both on unavalanched, forested strips and as a stunted variant on avalanche path margins.

Unvegetated portions, associated with rubbly colluvium and Regosolic soils on intensely active sites, may constitute up to 50% of EN2 tracts or up to 80% of tracts mapped as EN2+T or EN2+CR.

Discussion

In terms of landform surface expression, physiographic position, and vegetation cover, EN2 resembles the Wildflower 2 (WF2) and Whitehorn (WH3) Ecosites. However, in contrast to the Colluvium A characterizing EN2, WF2 occurs on colluvial landforms consisting of calcareous, medium textured colluvium (Colluvium C) and WH3 occurs on noncalcareous, medium textured colluvium (Colluvium B). Also, WF2 has Eutric Brunisols and a significant amount of Regosolic soils. The WH3 Ecosite, like EN2, has Dystric Brunisols but both sola and Ae horizons are thinner in the former. Regosolic soils are more extensive on WH3 than on EN2. The EN1 and EN3 Ecosites are differentiated from EN2 primarily by vegetation differences (Table 177) that reflect varying type and degree of colluvial activity. The Fairview 1 (FV1) Ecosite, where it occurs on noncalcareous, coarse textured colluvium (Colluvium A), is the Lower Subalpine counterpart of EN2.

EN3 - ENDLESS CHAIN 3 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, EN3, encompasses blankets and veneers of noncalcareous, coarse textured colluvium (Colluvium A) overlying inclined bedrock on steep valley walls. Exposed bedrock escarpments are subdominant. Colluviation, in the form of surface or soil creep, is characteristic and influences soil and vegetation development. A soil pattern characterizes EN3 in which Eluviated Dystric Brunisols are dominant and Orthic Dystric Brunisols and Orthic Regosols are subdominant. A charcteristic vegetation pattern occurs in which Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) is dominant and Engelmann spruce-subalpine fir/heather (O10) is subdominant.

Geomorphology

The EN3 Ecosite occurs on shallow, discontinuous, colluvial landforms consisting of noncalcareous, coarse textured colluvium (Colluvium A). Exposed bedrock forms the subdominant portion of the landscape. Underlying and exposed bedrock is predominantly Gog Group quartzites although three EN3 tracts north of Cascade Mountain in Banff overlie and contain material derived from quartz sandstone of the Rocky Mountain Group. Geomorphic activity on EN3 primarily consists of shallow colluviation, varying in intensity across the landscape. Avalanching and related processes also occur on tracts mapped as EN3A but usually in channeled tracks. Sheet erosion is extensive but of minor consequence. Locally, stream erosion in avalanched couloirs is more important to soil and vegetation development. Veneers of altered, medium textured eolian material (Eolian material B) occur sporadically, associated with stable sites. Rubble without fine earth material for soil development is common in some EN3 tracts, particularly those occurring below steep rock walls.

Topographically, EN3 displays long, linear, inclined slopes commonly ranging from 45 to >100%. These slopes consist of discontinuous colluvial veneers and blankets broken by patches of exposed bedrock. Tracts of EN3 with complex topography have linear slopes whose continuity is broken by one or more exceptionally steep bedrock escarpments. Tracts of EN3A often have couloirs that encompass avalanche tracks, avalanche starting zones, and associated intermittent stream channels. Tracts mapped as EN3F occur occasionally and are characterized by failed slopes that include failure of the unconsolidated material and partial failure of underlying bedrock.

Soils

Soils of the EN3 Ecosite are distributed in a pattern reflecting degree and intensity of surface colluviation and, to a lesser extent, avalanching. Eluviated Dystric Brunisols are dominant and reflect low intensity, infrequent colluvial and erosional processes. Orthic Dystric Brunisols and Orthic Regosols are subdominant. Orthic Dystric Brunisols occupy localities where surface modification is weak but eluvial (Ae) horizon development is retarded or has been destroyed. On localities where geomorphic activity is frequent and in-

Table 182 Pedon (Alberta No. 59) description of an Eluviated Dystric Brunisol of the EN3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1970, SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: EN3.

LOCATION: MILITARY GRID REF. 11 UNH 2520 4060; NTS MAP AREA 82N 15E.

CLIMATE: 2030 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 2 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=PA8157*VTH=06..

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), COLLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: COLLUVIAL, BOULDERY, AVALANCHED, BLANKET; SLOPE: 65% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING EAST, SITE AT MIDDLE POSITION, MODERATELY MOUNDED MICROTOPOGRAPHY,600 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, VERY RAPID SURFACE RUNOFF, SEEPAGE ABSENT; EXCESSIVELY STONY.

SPECIAL NOTES: SSN=6C8041*APH=015-049*PCF=4CB.16R(2)3CB.2SR(3-4)*THE BM2 WAS SAMPLED FROM 100-125CM*LFH=CB/BI-A*

H: 1 TO 0 CM, RANGE 1 TO 3 CM; MATRIX MOIST 10YR 3/2; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 7 CM, RANGE 5 TO 16 CM; MATRIX MOIST 10YR 6/2; SILT LOAM; WEAK, COARSE, PLATY STRUCTURE; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, FINE AND MEDIUM ROOTS; MANY, VERY FINE PORES; 80% GRAVELLY AND COBBLY COARSE FRAGMENTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

BM1: 7 TO 40 CM, RANGE 30 TO 40 CM; MATRIX MOIST 10YR 5/6, MATRIX MOIST 5YR 4/6; LOAMY COARSE SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; WEAK, FINE, SUBANGULAR BLOCKY SECONDARY STRUCTURE; LOOSE CONSISTENCE; ABUNDANT, VERY FINE ROOTS; 60% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, DIFFUSE HORIZON BOUNDARY.

BM2: 40 TO 125 CM; MATRIX MOIST 10YR 5/8; LOAMY COARSE SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; WEAK, FINE, SUBANGULAR BLOCKY SECONDARY STRUCTURE; LOOSE CONSISTENCE; FEW, MICRO AND MEDIUM ROOTS; 60% GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
H	3.7	27.70						
AE	4.8	1.80	19.7		3.9	1.0	0.1	0.1
BM1	5.4	0.70	6.7		1.3	0.4	0.1	0.1
BM2	4.6	0.60	7.9		0.5	0.2	<.1	0.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
H				
AE				
BM1	0.1		0.1	
BM2	0.2		0.1	

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS % PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	% OF SAMPLE V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
H														
AE					3	7	8	8	6	32		67	1	
BM1					15	21	17	18	7	78		22	0	
BM2	99	74	46	38	15	18	15	16	2	66		34	0	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
H													
AE		28.5	3.5										
BM1													
BM2		11.0	2.5									11	03

tense, Orthic Regosols are abundant. These localities include unvegetated rubbly sites and couloirs. Lithic phases of EN3 soils are common.

Soils of the EN3 Ecosite are rapidly to well drained and reflect, in their development, the acidic, rapidly pervious parent material. The Brunisolic soils have thick sola and strongly developed B horizons. Thick, well developed, eluvial (Ae) horizons occur in stable positions. The Orthic Regosols may have thin Ah horizons. Orthic Humo-Ferric Podzols occur occasionally and are associated with altered, medium textured eolian (Eolian material B) veneers on stable sites. A pedon illustrating Eluviated Dystric Brunisols of EN3 is described in Table 182.

Vegetation

Vegetation of the EN3 Ecosite is distributed in a pattern reflecting degree of colluvial activity, drainage, and elevation. Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) is dominant and occurs characteristically on more active, subxeric sites on southerly aspects. Engelmann spruce-subalpine fir/heather (O10) is subdominant and occurs more extensively on northerly aspects, at higher elevations, and on less active sites.

Juniper-willow (L2) and subalpine larch-subalpine fir/grouseberry-everlasting (C23) are accessory v.t.s, with L2 occurring on actively colluviating and avalanched localities. The C23 v.t. is important on several EN3 tracts of southwestern Banff, south of Hector Lake and Pipestone Pass. Heather-everlasting (L5) occurs in minor amounts but occasionally is quite common with tree islands (O10) on relatively stable, high elevation EN3 tracts. Also in minor amounts, subalpine fir-willow (S2) is associated with avalanched portions (EN3A). A plot representing vegetation of the pedon sample site described in Table 182 and illustrating O4 on EN3 is presented in Table 183 and Plate 109.

Table 183 Stand PA8157) illustrating the Engelmann spruce-subalpine fir-whitebark pine-lodgepole (04) v.t. of the EN3 Ecosite.

TREE LAYER	
Picea engelmannii	10
Pinus albicaulis	.5
TALL SHRUB LAYER	
Abies lasiocarpa	30
Picea engelmannii	15
SHRUB LAYER	
Abies lasiocarpa	30
Rhododendron albiflorum	.5
HERB-DWARF SHRUB LAYER	
Empetrum nigrum	10
Vaccinium membranaceum	25
Vaccinium scoparium	05
BRYOID LAYER	
Barbilophozia hatcheri	05
Barbilophozia lycopodioides	10
Cladonia arbuscula	.5
Cladonia deformis	.5
Cladonia ecmocyna	02
Cladonia pyxidata	.5
Cladonia verticillata	.5
Dicranoweisia crispula	.5
Dicranum acutifolium	35
Hypnum revolutum	.5
Paraleucobryum enerve	.5
Peltigera aphthosa	10
Peltigera malacea	.5
Rhizocarpon geographicum	.5
EPIPHYTES	
Letharia vulpina	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Unvegetated portions, associated with rubbly colluvium and Regosolic soils on intensely active sites, may constitute up to 50% of EN3 tracts, or up to 80% of tracts mapped as EN3+CR.

Discussion

In terms of landform surface expression, physiographic position, and vegetation cover, EN3 resembles the Wildflower 3 (WF3) and Whitehorn 5 (WH5) Ecosites. However, in contrast to the Colluvium A characterizing EN3, WF3 occurs on colluvial landforms consisting of calcareous, medium textured colluvium (Colluvium C), and WH5 occurs on noncalcareous, medium textured colluvium (Colluvium B). Also, WF3 has Eutric Brunisols. WH5, like EN3, has Dystric Brunisols but both sola and Ae horizons are thinner in the former. In addition, Regosolic soils are more extensive on WF3 and WH5 than on EN3. The EN1 and EN2 Ecosites are differentiated from EN3 primarily by vegetation differences (Table 177) that reflect varying type and degree of colluvial activity.

FR - FIRESIDE ECOSECTION

The Fireside (FR) Ecosection encompasses fluvial landforms comprised of calcareous, coarse, stratified fluvial material (Fluvial material B) in the Montane Ecoregion. Brunisolic soils associated with lodgepole pine forests characterize FR. This Ecosection is found mainly on the lower slopes of the Athabasca River valley in Jasper and the Bow and North Saskatchewan River valleys in Banff. It also occurs on the lower slopes of the Miette, Snake Indian, Maligne, and Rocky River valleys and the Moosehorn Creek valley in Jasper. In Banff, FR also occurs in the Lake Minnewanka valley.

Only one Ecosite (FR1) is recognized within the FR Ecosection. Its general features are outlined in Table 184.

FR1 - FIRESIDE 1 ECOSITE

Ecosite Concept

The FR1 Ecosite is characterized by fluvial fans and aprons consisting of calcareous, coarse, stratified fluvial material (Fluvial material B). Orthic and Eluviated Eutric Brunisols typify the soil component. Vegetation cover is dominated by the lodgepole pine/buf-

Table 184 General features of the Fireside 1 (FR1) Ecosite.

Ecosite	Landform	Soils	Vegetation
FR1	Fluvial material B; fan, apron	Eutric Brunisol	lodgepole pine forest

Table 185 Pedon (Alberta 1978 No. 89) description of an Orthic Eutric Brunisol of the FR1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: FR1.

LOCATION: MILITARY GRID REF. 11 UNG 9840 6860; NTS MAP AREA 82O 4E.

CLIMATE: 1390 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS GOOD RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 7 DEG(C) AT 50 CM IN JUNE.

VEGETATION: VPN=JD8003*VTNC6*..

SOIL SITE: PARENT MATERIAL 1: COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), FLUVIAL; LANDFORM CLASSIFICATION: FLUVIAL, FAN; SLOPE: 3% SIMPLE SLOPE OF CLASS 3 (2-5%), FACING NORTH, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,500 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, RAPIDLY PERVIOUS, SLOW SURFACE RUNOFF, SEEPAGE ABSENT; NONSTONY; NONROCKY.

SPECIAL NOTES: SSN=BW8006*APN=011-14*FLU=15*PCF=1GR(2-3)2GR(4)4GR,2CB(5)5GR,2CB,2ST(6)*CK2 HORIZON MAY BE A BURIED B OR AH*AE NOT SAMPLED,WEAKLY DEVELOPED.PRESENT ON ONLY ONE FACE OF PIT*LFH=FF*

LF: 4 TO 0 CM, RANGE 3 TO 5 CM; MATRIX MOIST 10YR 2/1; ABUNDANT, VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 2 CM, RANGE 0 TO 3 CM; MATRIX MOIST 7.5YR 5/4; SILT LOAM; VERY WEAK, COARSE, PLATY STRUCTURE; FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE AND MEDIUM ROOTS; GRAVELLY COARSE FRAGMENTS; BROKEN, ABRUPT HORIZON BOUNDARY.

BM: 2 TO 23 CM, RANGE 19 TO 23 CM; MATPIX MOIST 7.5YR 5/6; SILT LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STPUCTURE; VERY WEAK, FINE, SUBANGULAR BLOCKY SECONDARY STRUCTURE; FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE ROOTS; COMMON, VERY FINE PORES; GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK1: 23 TO 32 CM, RANGE 7 TO 13 CM; MATRIX MOIST 10YR 4/3; SANDY LOAM; STPUCTUPELESS, GRANULAR STPUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 10% GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK2: 32 TO 45 CM, RANGE 8 TO 20 CM; MATRIX MOIST 5YR 4/3; GRAVELLY SANDY LOAM; WEAK, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 50% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK3: 45 TO 75 CM; MATRIX MOIST 10YR 5/2; GRAVELLY SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; VERY FEW, VERY FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 70% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LF	6.3	30.20	
AE			
BM	7.0	1.70	1.4
CK1	7.7		67.8
CK2	7.7		64.0
CK3	7.9		73.7

CHEMICAL DATA (SURVEY)

	EXTRACT IRON (%)		EXTRACT ALUMINUM (%)	
HORIZON	1	2	1	2
LF				
AE				
BM	0.1		-.1	
CK1				
CK2				
CK3				

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS													
	% PASSING										% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE														
BM					2	3	5	7	6	23		55	22	
CK1	99			75	3	5	9	24	17	58		24	8	
CK2					11	10	15	18	9	63		28	9	
CK3	99	65	37	25	17	20	19	11	4	71		22	7	

PHYSICAL DATA

	MOISTURE STATUS (%)					ENGINEERING							
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE													
BM		28.1	14.2										
CK1		9.9	4.9									40	07
CK2													
CK3		8.7	2.5									11	01

faloberry/showy aster (C6) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s.

Geomorphology

The Montane Ecosite, FR1, encompasses fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). Irregular surfaces produced by channeling (Eroded modifier, C.S.S.C. 1978b) are common features. These fluvial deposits are generally moderately to extremely calcareous and reflect the calcareousness of their source materials. These materials are eroded from morainal, colluvial and rock slopes above. An exception occurs in the Miette River valley in Jasper where fluvial landforms comprised of noncalcareous, coarse, stratified fluvial material (Fluvial material A) are mapped as FR1. Here absence of lime is controlled by the lithology of the surrounding Miette Group bedrock. Geomorphologically, FR1 tracts are relatively stable as indicated by the degree of soil development.

Topographically, FR1 displays linear slopes on fans and aprons. Slopes commonly range from 2 to 30% with the gentler slopes confined to apron and fan toes on valley floors. Slope continuity is often broken by abandoned and active stream channels including their natural levee margins (Eroded modifier, C.S.S.C. 1978b).

Soils

Soils of the FR1 Ecosite are well drained and the degree of development of these soils reflects geomorphic stability. Orthic and Eluviated Eutric Brunisols are the dominant soils. Orthic and Cumulic Regosols are accessory soils that reflect a more active geomorphic environment. These soils occur near present and abandoned stream channels and may be subject to erosion or flooding during spring run-off and periods of high precipitation. Eutric Brunisols with Btj horizons indicating luvisolic tendencies were found on a few FR1 tracts in the Redearth and Whiskey Creek areas of Banff and the Mount Kerkeslin area of Jasper. These particular tracts tend to be finer textured at the surface than their modal FR1 counterparts. A pedon illustrating Orthic Eutric Brunisols of FR1 is described in Table 185 and shown in Color Plate 20. This pedon was sampled on the Sundance Creek fan in Banff.

Vegetation

The FR1 Ecosite is dominated by the closely related lodgepole pine/buffaloberry/showy aster (C6) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s that reflect the extensive effects of fire in the Montane Ecoregion. In Banff, lodgepole pine/dwarf bilberry (C9) occurs as an accessory v.t. on tracts of FR1 in

Table 186 Stand (JD8003) illustrating the lodgepole pine/buffaloberry/showy aster (C6) v.t. of the FR1 Ecosite.

TREE LAYER	
Picea glauca	.5
Pinus contorta	61
Populus tremuloides	.5
TALL SHRUB LAYER	
Picea glauca	.5
Salix bebbiana	.5
SHRUB LAYER	
Juniperus communis	.5
Juniperus horizontalis	.5
Juniperus scopulorum	.5
Populus tremuloides	.5
Shepherdia canadensis	07
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	.5
Antennaria racemosa	.5
Aquilegia flavescens	.5
Aster conspicuus	35
Calamagrostis rubescens	15
Calypso bulbosa	.5
Carex concinna	.5
Carex concinnoides	.5
Castilleja miniata	.5
Corralorhiza trifida	.5
Cornus canadensis	02
Elymus innovatus	20
Epilobium angustifolium	.5
Fragaria virginiana	.5
Hedysarum sulphurescens	.5
Lathyrus ochroleucus	05
Linnaea borealis	15
Pyrola secunda	.5
Pyrola virens	.5
Ribes lacustre	.5
Rosa acicularis	01
Vaccinium vitis-idaea	.5
Vicia americana	03
BRYOID LAYER	
Amblystegium serpens	.5
Barbilophozia hatcheri	.5
Brachythecium spp.	.5
Bryoerythrophyllum recurvirostrum	.5
Bryum spp.	.5
Candellariella aurella	.5
Campylium chrysophyllum	.5
Ceratodon purpureus	.5
Cladonia cornuta	.5
Cladonia multiformis	.5
Cladonia pyxidata	.5
Drepanocladus uncinatus	.5
Eurhynchium pulchellum	.5
Hylocomium splendens	60
Hypnum revolutum	.5
Peltigera aphthosa	01
Peltigera canina	.5
Pleurozium schreberi	.5
Pohlia nutans	.5
Pylaisiella polyantha	.5
Tortula norvegica	.5
EPIPHYTES	
Bacidia acclinis	.5
Caloplaca holocarpa	.5
Cladonia ecmocyna	.5
Lecanora coilocarpa	.5
Parmelia exasperatula	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

the Bow River valley between Johnston Canyon and the Banff townsite. In Jasper, the lodgepole pine/green alder/feathermoss (C10) and lodgepole pine/feathermoss (C11) v.t.s occur in minor amounts on FR1 tracts in the Miette River Valley. A stand illustrating the C6 v.t. on FR1 is described in Table 186 and shown in Plate 110 and represents the vegetation at the pedon sample site described above in Table 185.

Discussion

The FR1 Ecosite may appear similar to the Athabasca 1 (AT1) Ecosite but AT1 can be differentiated because of the coarser, more cobbly glaciofluvial materials. The Altrude 1 (AL1) Ecosite is the Lower Subalpine counterpart of FR1.

FV - FAIRVIEW ECOSECTION

The Fairview (FV) Ecosection encompasses steep, usually linear, colluvial landforms comprised of either noncalcareous, coarse textured colluvium (Colluvium A) or noncalcareous, medium textured colluvium (Colluvium B) in the Lower Subalpine portion of the Subalpine Ecoregion of Banff and Jasper. It occurs predominantly in the Main Ranges on or below steep, rocky, valley walls that are geologically dominated by noncalcareous strata.

Varying type and degree of colluvial activity, aspect, exposure, and lithology govern soils and vegetation development and distribution. The FV Ecosection is characterized by Dystric Brunisols associated with hetergeneous avalanche complex vegetation and Engelmann spruce-subalpine fir forest.

The Ecosites (FV1, FV2) are recognized within the FV Ecosection and are separated primarily on vegetation differences. Table 187 outlines the general features of the FV Ecosites. Fig. 40 for the Endless Chain (EN) Ecosection shows, schematically, the physiographic positions of the FV1 and FV2 Ecosites.

FV1 - FAIRVIEW 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, FV1, encompasses avalanched colluvial landforms comprised of either noncalcareous, coarse textured colluvium (Colluvium A) or noncalcareous, medium textured colluvium (Colluvium B). These exist as blankets and veneers overlying inclined bedrock on steep valley walls and as aprons along slope bases at major slope breaks. Snow avalanching is characteristic and governs the distribution of vegetation and, to a lesser extent, soils. A soil pattern in which Eluviated Dystric Brunisols are dominant and Orthic Dystric Brunisols and Orthic Regosols are subdominant typifies and the soil component of FV1. Avalanched segments dominate and are characterized by a heterogeneous complex of v.t.s that include subalpine fir-willow (S2), willow-dwarf birch-shrubby cinquefoil (S10), hairy wild rye-wild strawberry-fireweed (H5), aspen/hairy wild rye-showy aster (C22) plus intergrades collectively called Avalanche Complex 1. Forested strips and patches between avalanche tracks and fringing runout zones are subdominant and best represented by the Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/false azalea (C14) v.t.s.

Geomorphology

The FV1 Ecosite occurs on blankets, veneers and aprons comprised of either noncalcareous, coarse textured colluvium (Colluvium A) or noncalcareous, medium textured colluvium (Colluvium B). Source bedrock on FV1 tracts comprised of Colluvium A is predominantly Gog Group quartzite. Miette Group or noncalcareous Mesozoic strata dominate tracts comprised of noncalcareous, medium textured colluvium (Colluvium B). Several FV1 tracts contain admixtures of the two colluvial material genetic units. More than 50% of FV1 is modified by snow avalanching. Avalanching of such areal extent usually occurs with coalescing, unconfined avalanche paths, or as runout zones below the length of a cliff. Gully-like channeled avalanche tracks (chutes) are common as well. Perla and Martinelli (1975) define snow avalanche zone terminology.

Genetic material stability within FV1 tracts is greatest on portions unaffected by avalanching, but the unconfined avalanche tracks are almost as stable. Together these components make up a majority of the area of most FV1 tracts. Instability is of two kinds. Erosion of unconsolidated material occurs, though infrequently, on steep avalanche starting zones

Table 187 General features of the Fairview (FV) Ecosites.

Ecosite	Landform	Soils	Vegetation
FV1	Colluvium A,B; blanket, veneer, apron	Dystric Brunisol > Regosolic	Avalanche Complex 1 > Engelmann spruce-subalpine fir forest
FV2	Colluvium A,B; blanket, veneer	Dystric Brunisol	Engelmann spruce-subalpine fir forest

and on walls of channeled tracks. It is usually evidenced by sparsely vegetated patches. Deposition is a more common process and frequently includes material derived from bedrock exposures high on, or above the FV1 tract. Talus occurs as part of the FV1 Ecosite concept, its location and extent controlled by the cliffs above. Material carried by avalanching is distributed downslope to gentler runout zones. Colluvial material is modified by intermittent streams below couloirs and on avalanche runout zones. Fluvial deposits, occurring as thin veneers, and layers interbedded with colluvium, are most abundant below channeled tracks and couloirs. This material is a weakly sorted variant of noncalcareous, coarse, stratified fluvial material (Fluvial material A), and like the colluvium, is either medium or coarse textured with a high content of angular coarse fragments. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically on the subdominant unavalanched segments of the landscape. Rubble without fine earth material for soil development is common on some FV1 tracts, particularly, those occurring as aprons below steep rock walls.

Topographically, FV1 displays long, linear inclined slopes commonly ranging from 45 to 90%. Slopes <45% occur on lower slopes and toes of colluvial aprons. Surface form is controlled by deposition and underlying bedrock. The colluvial material deposits are generally shallowest (veneers) at the tops of slopes and deepen downslope to form aprons along slope bases at major slope breaks. Colluvial aprons also occur below steep rock walls. Shallow channels and accompanying levees, constructed by intermittent streams, are often associated with a wide range of gullying on avalanche tracks. Colluvial veneer landforms dominate tracts mapped as FV1X.

Soils

Soil distribution and development on the FV1 Ecosite is related to genetic material stability as influenced by avalanching and associated processes. A soil pattern, in which Eluviated Dystric Brunisols are dominant and Orthic Dystric Brunisols and Orthic Regosols are subdominant, characterizes FV1. Eluviated Dystric Brunisols occur where geomorphic activity is least frequent or intense, especially on the forested segments or avalanched segments without cliffs above. Orthic Dystric Brunisols occupy localities where surface modification is weak but sufficient to retard or destroy eluvial (Ae) horizon development. On localities where erosion or deposition is frequent and intense, Orthic Regosols are abundant.

Soils of the FV1 Ecosite are rapidly to moderately well drained and reflect, in their development, their acidic, medium and coarse textured parent materials. The Brunisols have moderately to strongly developed B horizons. The Eluviated Dystric Brunisols have well developed eluvial (Ae) horizons. Some Orthic Dystric Brunisols and Orthic Regosols may have thin Ah horizons. Orthic Humic Regosols occur in minor amounts on avalanched segments; Orthic Humo-Ferric Podzols occur occasionally on forested segments and are associated with veneers of altered, medium textured eolian material (Eolian material P). Lithic soil phases dominate tracts mapped as FV1X. A pedon illustrating Eluviated Dystric Brunisols of FV1 is described in Table 188 and shown in Color Plate 21. This pedon was sampled on an east-facing slope above Cirque Lake in Banff.

Vegetation

Vegetation distribution on the FV1 Ecosite is governed by the frequency and intensity of avalanching. Avalanched segments dominate and are characterized by a heterogeneous complex of v.t.s that include subalpine fir-willow (S2), willow-dwarf birch-shrubby cinquefoil (S10), hairy wild rye-wild strawberry-fireweed (H5), aspen/hairy wild rye-showy aster (C22), plus intergrades. The S2 v.t. is most abundant and extensive on FV1 but the other avalanche v.t.s plus intergrades occur occasionally. A plot illustrating the S2 v.t. on avalanched segments of FV1 is described in Table 189 and shown in Plate 111 and represents vegetation at the pedon sample site described above in Table 188. Tracts of FV1 that have been modified by fire, mapped as FV1B, occur between Fortress Lake and the confluence of the Athabasca and Chaba Rivers in Jasper. Unavalanched or infrequently avalanched segments may constitute up to 50% of FV1 tracts and occur as forested strips between avalanche tracks, and as patches along lower slopes fringing avalanche runout zones. The Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/false azalea (C14) v.t.s are most abundant on these segments. Unvegetated portions are associated with rubbly colluvium and Regosolic soil on intensely active sites.

Discussion

In terms of landform surface expression, physiographic position and vegetation cover, FV1 resembles the Sawback 1 (SB1) Ecosite. However, rather than Colluvium A and B characterizing FV1, SB1 occurs on colluvial landforms consisting of calcareous, medium textured colluvium (Colluvium C) and has Eutric, rather than Dystric, Brunisols. The FV1 Ecosite is separated from the FV2 Ecosite primarily on vegetation differences (Table 187) that reflect

Table 188 Pedon (Alberta 1978 No. 70) description of an Eluviated Dystric Brunisol of the FV1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: FV1.

LOCATION: MILITARY GRID REF. 11 UNH 2530 4010; NTS MAP AREA 82N 15E.

CLIMATE: 1910 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=DJB001*VTN=52 VARIANT*..

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), COLLUVIAL, QUARTZITE; LANDFORM CLASSIFICATION: COLLUVIAL AVALANCHED, APRON; SLOPE: 60% SLOPE OF CLASS 8 (46-70%), FACING EAST, SITE AT MIDDLE POSITION, 200 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; EXCEEDINGLY STONY; NON-ROCKY.

SPECIAL NOTES: SSN=WT8149*APN=015-050*RLU=15*PCF=4AGR,3ACB,1ST(2-3)5AGR,4ACB,2ST(4)4AGR,2ACB,1CB,1ST(5)*LFM=CB/R1-A*

LF: -3 TO 0 CM, RANGE 5 TO 0 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/1; VERY FEW, FINE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AE: 0 TO 14 CM, RANGE 12 TO 17 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 6/2; GRAVELLY SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY WEAK, COARSE, PLATY SECONDARY STRUCTURE; PLENTIFUL, FINE AND MEDIUM AND COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BM: 14 TO 45 CM, RANGE 25 TO 35 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/4; GRAVELLY SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; PLENTIFUL, FINE AND MEDIUM ROOTS; IRREGULAR, CLEAR HORIZON BOUNDARY; EXTREMELY ACID <4.5 FIELD PH.

BC1: 45 TO 87 CM, RANGE 35 TO 45 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/4; VERY GRAVELLY SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FEW, FINE ROOTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

BC2: 87 TO 110 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6; GRAVELLY SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FEW, FINE ROOTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	3.7	36.20						
AE	3.9	4.10	25.1		2.5	1.7	-.1	0.3
BM	3.8	0.90	11.3		1.1	0.6	-.1	0.1
BC1	5.0		13.8		1.3	0.4	-.1	0.1
BC2	4.6		19.4		1.1	0.3	-.1	0.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	0.1		-.1	
BC1				
BC2				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	% OF SAMPLE 50-2U SILT	% OF SAMPLE 2U CLAY	% OF SAMPLE 0.2U CLAY
LF														
AE					6	11	12	14	8	51		42	7	
BM					10	15	15	16	8	64		29	7	
BC1					10	12	14	17	9	62		31	7	
BC2	99	47	26	21	10	11	14	19	10	64		30	6	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATH	0.33 ATH	15 ATH	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE		24.5	8.7										
BM													
BC1													
BC2		14.6	1.9									11	02

Table 189 Stand (DJ8001) illustrating the subalpine fir-willow (S2) v.t. of the FV1 Ecosite.

SHRUB LAYER	
Abies lasiocarpa	38
Alnus crispa	05
Menziesia glabella	20
Picea engelmannii	22
Salix glauca	05
HERB-DWARF SHRUB LAYER	
Vaccinium membranaceum	.5
Vaccinium scoparium	.5
BRYOID LAYER	
Ceratodon purpureus	.5
Cladonia cornuta	.5
Cladonia ecmocyna	01
Cladonia fimbriata	.5
Cladonia gonecha	.5
Cladonia mitis	05
Cladonia vardilatata	01
Cladonia spp.	.5
Dicranum fuscescens	.5
Dicranum scoparium	.5
Nephroma bellum	.5
Peltigera aphthosa	08
Peltigera malacea	.5
Peltigera spuria	.5
Pleurozium schreberi	20
Pohlia nutans	.5
Polytrichum juniperinum	.5
Tortula ruralis	.5
Barbilophozia hatcheri	05
Barbilophozia lycopodioides	05

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

varying type and degree of colluvial activity. The Endless Chain 2 (EN2) and Whitehorn 3 (WH3) Ecosites are the Upper Subalpine counterparts of FV1.

FV2 - FAIRVIEW 2 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, FV2, encompasses blankets and veneers consisting of either noncalcareous, coarse textured colluvium (Colluvium A) or noncalcareous, medium textured colluvium (Colluvium B) overlying inclined bedrock on steep valley walls. The soils are dominated by Orthic and Eluviated Dystric Brunisols and suggest by their development that colluviation is not sufficiently active to prevent profile development. Eluviated Dystric Brunisols are the most abundant soils associated with FV2. Likewise, vegetation is successionally mature and is dominated by the Engelmann spruce-subalpine fir/feathermoss (C13), Engelmann spruce-subalpine fir/false azalea (C14), and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s. The C13 v.t. is most abundant.

Geomorphology

The FV2 Ecosite occurs on blankets and veneers consisting of either noncalcareous, coarse textured colluvium (Colluvium A) or noncalcareous, medium textured colluvium (Colluvium B) overlying inclined bedrock on steep valley walls. Source bedrock on FV1 tracts consisting of Colluvium A is predominantly Gog Group quartzite. Miette Group or noncalcareous Mesozoic strata dominate tracts characterized by Colluvium B. Several FV2 tracts contain admixtures of the two colluvial genetic material units. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically and are most abundant on FV2 tracts of western Banff and southwestern Jasper. Erosional and colluvial processes have removed or incorporated most of the eolian material which provides the evidence of wind blown accumulations. Till occasionally underlies colluvial material along lower, more gentle slopes of FV2 tracts. Thin fluvial deposits, generally a weakly sorted variant of noncalcareous, coarse, stratified fluvial material (Fluvial material A), occasionally are interbedded with colluvium on avalanched portions of tracts mapped as FV2A.

Topographically, FV2 displays long, linear, inclined slopes commonly ranging from 45 to 90%. Surface form is controlled by deposition and underlying bedrock. The colluvial deposits are generally shallowest (veneers) at the tops of slopes and deepen downslope. Colluvial aprons occur occasionally along slope bases at major slope breaks.

Soils

The soils of the FV2 Ecosite reflect in their development, the acidic, medium and coarse textured parent materials and stable geomorphic conditions. Eluviated Dystric Brunisols are more common than Orthic Dystric Brunisols but the latter dominates a few tracts. These well to moderately well drained soils have moderately to strongly developed B horizons. Well developed eluvial (Ae) horizons are generally present but Orthic Dystric Brunisols occur in localities where surface disturbances are sufficient to inhibit or destroy Ae development. Orthic Humo-Ferric Podzols are accessory soils and are associated with veneers of altered, medium textured eolian material (Eolian material B). A pedon illustrating Eluviated Dystric Brunisols characterizing FV2 is described in Table 190 and shown in Color Plate 22. This pedon was sampled on a west-facing slope above the south end of Peyto Lake in Banff.

Vegetation

Vegetation cover of the FV2 Ecosite reflects stable geomorphic conditions. The Engelmann spruce-subalpine fir/feathermoss (C13), Engelmann spruce-subalpine fir/false azalea (C14), and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s are dominant. The C13 v.t. is the most abundant but some FV2 tracts are dominated by C14 or C21. Tracts of FV2 that have been modified by

Table 190 Pedon (Alberta 1978 No. 83) description of an Eluviated Dystric Brunisol of the FV2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: FV2.

LOCATION: MILITARY GRID REF. 11 UNH 3350 2910; NTS MAP AREA 82N 10E.

CLIMATE: 1880 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 3 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VPN=JE8168*VTN=C13*.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, SANDY, EXTREMELY TO STRONGLY ACIDIC (PH.5.5), COLLUVIAL; LANDFORM CLASSIFICATION: COLLUVIAL, BLANKET; SLOPE: 84% SIMPLE SLOPE OF CLASS 9 (71-100%), FACING WEST, SITE AT LOWER SLOPE POSITION, MODERATELY MOUNDED MICROTOPOGRAPHY,150 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; EXCEEDINGLY STONY; SLIGHTLY ROCKY.

SPECIAL NOTES: SSN=WT8162*APN=783-88*RLU=15*PCF=4AGR,3ACB,2ST(3)4AGR,2ACB,1ST(4)4AGR,2ACB,2ST(5)7AGR,3ACB(6)5AGR,3ACB,2ST(7)*LFH=CB/RS*

LF1: 38 TO 23 CM, RANGE 13 TO 17 CM; MATRIX MOIST 7.5YR 7/6, MATRIX MOIST 7.5YR 4/2; ABUNDANT, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

LF2: 23 TO 0 CM, RANGE 21 TO 25 CM; MATRIX MOIST 10YR 2/1; ABUNDANT, MICRO AND VERY FINE AND FINE AND MEDIUM AND COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AE1: 0 TO 11 CM, RANGE 0 TO 12 CM; MATRIX MOIST 10YR 5/1; GRAVELLY FINE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AE2: 11 TO 34 CM, RANGE 20 TO 25 CM; MATRIX MOIST 10YR 6/3; GRAVELLY SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BM1: 34 TO 104 CM, RANGE 65 TO 75 CM; MATRIX MOIST 7.5YR 5/4, MATRIX MOIST 7.5YR 6/6; GRAVELLY SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY WEAK, MEDIUM, ANGULAR BLOCKY SECONDARY STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, ABRUPT HORIZON BOUNDARY; EXTREMELY ACID <4.5 FIELD PH.

BM2: 104 TO 121 CM, RANGE 15 TO 19 CM; MATRIX MOIST 7.5YR 5/6; VERY GRAVELLY LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; VERY FEW, VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

BM3: 121 TO 145 CM; MATRIX MOIST 7.5YR 5/6; GRAVELLY LOAMY SAND, STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; VERY FEW, VERY FINE AND FINE ROOTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF1	4.6	42.20						
LF2	3.5	39.60						
AE1	3.3	2.20	15.1		3.0	1.2	<.1	0.1
AE2	3.7	1.00	8.5		1.6	0.8	0.1	0.1
BM1	4.2	1.40	10.4		2.0	0.8	0.1	<.1
BM2								
BM3	4.6	1.40	9.3		2.7	0.3	<.1	<.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2
LF1				
LF2				
AE1				
AE2				
BM1	0.2		0.1	
BM2				
BM3	0.1		<.1	

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF1														
LF2														
AE1					6	10	16	20	7	61		34	5	
AE2					10	11	15	17	7	60		37	3	
BM1					10	11	14	21	8	64		32	2	
BM2														
BM3	99			14	9	12	18	23	6	80		18	2	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF1													
LF2													
AE1		16.1	4.7										
AE2													
BM1													
BM2													
BM3		7.2	2.8									11	

fire, mapped as FV2B, are dominated by pine v.t.s. These occur in the Moosehorn Creek valley and on the lower slopes of Endless Chain in Jasper. Many tracts have up to 50% of their area modified by avalanching (mapped as FV2A), and are characterized by avalanche v.t.s such as subalpine fir-willow (S2). A stand representing the Engelmann spruce-subalpine fir/feathermoss (C13) v.t. on FV2 is described in Table 191 and shown in Plate 112 and represents vegetation at the pedon sample site described above in Table 190.

Table 191 Stand (JE8165) illustrating the Engelmann spruce-subalpine fir/feathermoss (C13) v.t. of the FV2 Ecosite.

TREE LAYER	
Abies lasiocarpa	20
Picea engelmannii	25
TALL SHRUB LAYER	
Abies lasiocarpa	08
Picea engelmannii	02
SHRUB LAYER	
Abies lasiocarpa	11
Menziesia glabella	01
Picea engelmannii	03
BRYOID LAYER	
Bacidia obscurata	.5
Barbilophozia hatcheri	.5
Barbilophozia lycopodioides	.5
Cladonia chlorophaea	.5
Cladonia ecmocyna	.5
Cladonia pyxidata	.5
Dicranum acutifolium	.5
Dicranum brevifolium	.5
Dicranum scoparium	.5
Drepanocladus uncinatus	.5
Hylocomium splendens	85
Mnium spinulosum	.5
Lepraria membranacea	.5
Peltigera aphthosa	02
Peltigera collina	.5
Pleurozium schreberi	.5
Pohlia nutans	.5
Ptilium crista-castrensis	.5
Tortula ruralis	.5
EPIPHYTES	
Bryoria fremontii	.5
Calicium sp.	.5
Cetraria pinastri	.5
Hypogymnia austerodes	.5
Lecanora collocarpa	.5
Letharia vulpina	.5
Parmeliopsis ambigua	.5
Parmelia spp.	.5
Usnea subfloridana	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

In terms of landform surface expression, physiographic position, and vegetation cover, FV2 resembles the Sawback 2 (SB2) Ecosite. However, rather than the Colluvium A and B characterizing FV2, SB2 occurs on landforms consisting of calcareous, medium textured colluvium (Colluvium C) and also has Eutric Brunisols and a significant amount of Regosolic soils rather than Dystric Brunisols. The FV1 Ecosite is separated from FV2 primarily by vegetation differences (Table 187) that reflect varying type and degree of colluvial activity. The Endless Chain 1 (EN1) and Whitehorn 2 (WH2) Ecosites are the Upper Subalpine counterparts of FV2.

GA - GARONNE ECOSECTION

The Garonne (GA) Ecosection encompasses hummocky colluvial landforms comprised of calcareous, medium textured landslide material in the Montane Ecoregion. Brunisolic and Regosolic soils associated with lodgepole pine forest characterize GA. The only examples of this Ecosection in each park occur on the lower slopes of the Athabasca River valley in the vicinity of Garonne Creek in Jasper and, in Banff, on the lower slopes of the Bow River valley between Hillsdale and Johnston Creek. The GA Ecosection is represented by only one Ecosite (GA1) and its general features are outlined in Table 192 and Plate 113.

GA1 - GARONNE 1 ECOSITE

Ecosite Concept

The GA1 Ecosite is characterized by a calcareous, medium textured, hummocky colluvial landform (landslide) with rapidly to well drained Orthic Eutric Brunisols and Orthic Regosols, and with lodgepole pine forest.

Geomorphology

The GA1 Ecosite is characterized by weakly to extremely calcareous, stabilized landslide (colluvial) deposits with hummocky relief. Slopes are complex and commonly range from 15 to 45%. These postglacial deposits are medium textured with a high content of variable sized angular and subangular coarse fragments. They also have a high proportion of the surface occupied by stones and boulders. In Jasper, the slide originated from the

Table 192 General features of the Garonne 1 (GA1) Ecosite.

Ecosite	Landform	Soils	Vegetation
GA1	Landslide material; hummocky	Brunisolic, Regosolic	lodgepole pine forest

Table 193 Pedon (Alberta 1978 No. 65) description of Orthic Eutric Brunisols of the GA1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: GA1.

LOCATION: MILITARY GRID REF. 11 U+B 8290 7670; NTS MAP AREA 820 4H.

CLIMATE: 1400 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS MODERATE RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 3 DEG(C) AT 45 CM IN MAY.

VEGETATION: VPN=JE0004 VTH=C19.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN, UNDIFFERENTIATED OR UNDETERMINED; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, FRAGMENTAL (STONES,COBBLES AND GRAVEL) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), WEAKLY CALCAREOUS (1 TO 6% CACO3), COLLUVIAL; LANDFORM CLASSIFICATION: COLLUVIAL, HUMMOCKY; SLOPE: 10% COMPLEX SLOPE OF CLASS 5 (10-15%), FACING NORTH, SITE AT UPPER SLOPE POSITION, MODERATELY ROUNDED MICROTOPOGRAPHY:20 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY.

SPECIAL NOTES: SSH=WTB00I=ARH=011-16=PCF=1AB(2-3)4A6,4AC(4)8ST(5)=NO SAMPLEOF AE OR ECK=LFH=CH=

LF: 4 TO 0 CM, RANGE 3 TO 5 CM; MATRIX MOIST 5YR 2.5/1; PLENTIFUL, FINE AND MEDIUM ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 1 CM, RANGE 0 TO 2 CM; MATRIX MOIST 7.5YR 6/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BM: 1 TO 10 CM, RANGE 7 TO 14 CM; MATRIX MOIST 5YR 5/8, MATRIX MOIST 10YR 5/8; SILT; VERY WEAK, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

2BC: 10 TO 22 CM, RANGE 10 TO 14 CM; MATRIX MOIST 5YR 6/4, MATRIX MOIST 7.5YR 6/4; SILT LOAM; VERY WEAK, FINE, GRANULAR STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

2CK: 22 TO 45 CM; MATRIX MOIST 7.5YR 5/4; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, COARSE ROOTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.6	40.70							
AE									
BM	5.3	2.60		33.9		8.6	0.9	0.1	0.2
2BC	6.7		1.0						
2CK									

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	80-2U SILT	2U CLAY	0.2U CLAY
LF														
AE														
BM	99	94	90	88						11		85	4	
2BC										22		67	11	
2CK														

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE													
BM		44.3	16.6			0.0	0.0					4A	1D
2BC		30.7	9.5										
2CK													

west face of a mountain in the Colin Range, depositing limestone debris downslope. The upper portion of this landslide overlies a till bench whereas the lower portion overlies fluvial deposits. The upper and lower portions are separated by a steep till slope mapped as NY3. In Banff, the landslide originated from the west face of Mount Ishbel. The upper portion of this slide failed en masse whereas the lower portion crumbled and deposited debris down slope to and across the Bow River. The debris of this slide is dominantly calcareous siltstones and shales of the Sulphur Mountain Formation. The colluvial material is overlain by altered, medium textured eolian material (Eolian material B) in Banff and by the calcareous, medium textured eolian material (Eolian material A) in Jasper.

Soils

The GA1 Ecosite is characterized by rapidly to well drained Orthic Eutric Brunisols and Orthic Regosols on weakly to extremely calcareous parent materials. These soils exhibit silt loam to loam (medium) textures throughout the solum. Orthic Regosols are more common than Orthic Eutric Brunisols in Jasper and are distinguished by the presence of carbonates in all soil horizons due to a calcareous, medium textured eolian material (Eolian material A) overlying the colluvium. In Banff, Orthic Eutric Brunisols are dominant and have an acid to neutral upper solum (Eolian material B). A pedon illustrating Orthic Eutric Brunisols of GA1 is described in Table 193 and shown in Color Plate 23.

Vegetation

The GA1 Ecosite is dominated by subxeric to mesic v.t.s: lodgepole pine/juniper/bearberry (C3), lodgepole pine/buffaloberry/showy aster (C6), and lodgepole pine/buffaloberry/twinflower (C19). The Douglas fir/hairy wild rye (C1) v.t. occupies a smaller area. In Jasper, the C3 v.t. is predominant, with the C1 v.t. less common, whereas in Banff, the C6 and C19 v.t.s. are predominant. The aspen/hairy wild rye-peavine (C16) and C1 v.t.s. occur in minor amounts as an accessory in Banff. On steep, exposed slopes in Banff, minor amounts of bluebunch wheatgrass-hairy wild rye-showy aster (H19) v.t. occur. A stand illustrating the C19 v.t. on GA1 is described in Table 194 and shown in Plate 21.

Discussion

The GA1 Ecosite has only one mappable occurrence within each park. The GA1 Ecosite is defined as occurring in the Montane Ecoregion which distinguishes it from the similar Ishbel 1 (IB1) Ecosite which occurs in the Lower Subalpine.

Table 194 Stand (JE8004) illustrating the lodgepole pine/buffaloberry/twinflower (C19) v.t. of the GA1 Ecosite.

TREE LAYER	
Picea glauca	05
Pinus contorta	25
Populus tremuloides	01
TALL SHRUB LAYER	
Picea glauca	.5
SHRUB LAYER	
Picea glauca	5
Ribes lacustre	.5
Shepherdia canadensis	55
HERB-DWARF SHRUB LAYER	
Arnica cordifolia	.5
Aster conspicuus	.5
Calamagrostis rubescens	10
Calypso bulbosa	.5
Cornus canadensis	05
Elymus innovatus	05
Fragaria virginiana	.5
Habenaria obtusata	.5
Lathyrus ochroleucus	.5
Ledum groenlandicum	.5
Linnaea borealis	10
Pyrola asarifolia	.5
Pyrola secunda	.5
Rosa acicularis	.5
Spiraea lucida	.5
Stenanthium occidentale	.5
BRYOID LAYER	
Dicranum polysetum	.5
Drepanocladus uncinatus	.5
Hylocomium splendens	15
Mnium spinosum	.5
Pleurozium schreberi	45
Ponlia nutans	.5
Pylaisiella polyantha	.5
Ptilidium pulcherrimum	.5
EPIPHYTES	
Bryoria glabra	.5
Alectoria sarmentosa ssp. sarmentosa	.5
Caloplaca holocarpa	.5
Catraria pinastri	.5
Hypogymnia austerodes	.5
Hypogymnia physodes	.5
Lecanora hageni	.5
Letharia vulpina	.5
Parmelia sulcata	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

GT - GOAT ECOSECTION

The Goat Ecosection encompasses steeply sloping morainal landforms comprised primarily of calcareous, medium textured till (Till C) throughout the Lower Subalpine portion of the Subalpine Ecoregion in Banff and Jasper. Erosional processes, including surface erosion (e.g. gullying, sheet erosion, shallow colluviation) and undercutting by streams, are or have recently been active and control the landscape features. The GT Ecosection occurs primarily on valley walls, benchlands and narrow valley floors.

Weakly to moderately developed Eutric Brunisols, often exhibiting rudimentary luvisolic tendencies, are generally dominant. However, Regosolic soils, reflecting surface instability and erosion, are subdominant. Vegetation cover is characterized by dry to moist lodgepole pine forest, white spruce open forest, mixed coniferous open forest, dry grassland, and low shrub-herb meadow. Distribution of vegetation types is related to degree of surface erosion, steepness of slope, exposure, and aspect.

Two Goat Ecosites are differentiated. The GT1 Ecosite generally has unidirectional slopes with moderate erosion and open forests. The GT2 Ecosite displays a landscape pattern (primarily vegetational) governed by steepness of slope, exposure, aspect, and degree of erosion. For convenience and standardization, the two distinctly different GT2 segments are termed northerly and southerly aspects. The general features of the Goat Ecosites are presented in Table 195. Figs. 41 and 52 show the physiographic positions of GT1 and GT2. These figures are applicable to Front Range areas of Banff and Jasper, but GT1 also occurs in the Main Ranges.

GT1 - GOAT 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, GT1, occurs on morainal blankets consisting of calcareous, medium textured till (Till C) overlying inclined bedrock on valley walls. Its long, steep, linear slopes are characterized by surface erosion including primarily gullying, sheet erosion, and shallow colluviation (soil creep). These modifying processes influence soil and vegetation development. Thus, a soil pattern in which Orthic Eutric Brunisols are dominant and Orthic Regosols are subdominant typifies the soil component of GT1. Vegetation is characterized by open forest, best represented by an open forest variant of the lodgepole pine/juniper/bearberry (C3) v.t., with lesser amounts of Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) and white spruce/juniper/bearberry (O17) v.t.s. The GT1 Ecosite occurs primarily on southerly aspects and is associated with calcareous strata throughout Banff and Jasper.

Geomorphology

The GT1 Ecosite is typified by morainal blankets consisting of calcareous, medium textured till (Till C) overlying inclined bedrock. Due to the active and recently active erosion on these slopes, eolian veneers are usually absent but other erosion products have accumulated locally. Calcareous, coarse, stratified fluvial material (Fluvial material B) occurs, usually along the bases of gullied slopes. Veneers of calcareous, medium textured colluvium (Colluvium C), derived primarily from the till, are common on and below localities where shallow colluviation is or has recently been occurring.

Topographically, GT1 displays long linear slopes of till mantling inclined bedrock that forms valley walls. Slopes commonly range from 45 to 70% and are usually dissected by subparallel gullies. Small fluvial fans and aprons emanating from gully mouths along slope bases may be included in GT1 tracts. Erosional products also occur locally as fluvial and colluvial veneers. A few GT1 tracts have irregular, hummocky, or ridged surfaces with slopes ranging from 30 to 70%. These tracts are situated on rounded spurs (shoulders), where surface form is controlled by underlying bedrock, and on failed slopes. Morainal veneers occur occasionally on both linear and irregular slopes and dominate on GT1X tracts. Bedrock outcrops occur sporadically and are common on tracts mapped as GT1+R.

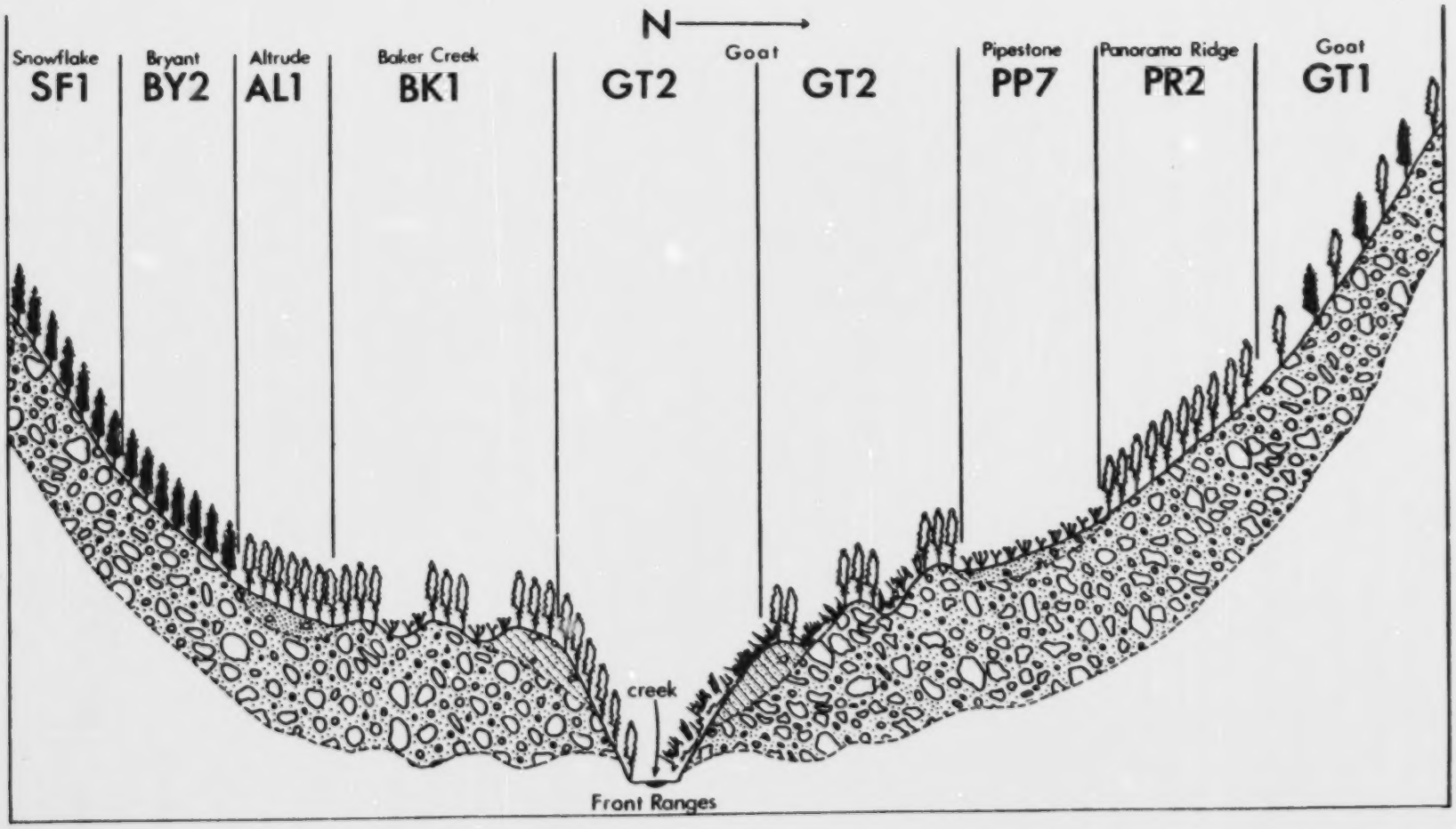
Soils

Soil development and distribution reflect the surface erosional processes that characterize GT1. The soil pattern, in which Orthic Eutric Brunisols are dominant and Orthic Regosols are subdominant, reflects varying degrees of erosion across the rapidly to well drained landscape. Localities where erosion is slight, intermittent, or has recently ceased, have Orthic Eutric Brunisols. These soils generally have weakly developed Bmk horizons. Eluvial (Ae) horizons are absent or weakly developed. Eluviated Eutric Brunisols, as accessory soils, and Brunisolic Gray Luvisols, in minor amounts, occur on the most stable localities within tracts mapped as GT1.

Table 195 General features of the Goat (GT) Ecosites.

Ecosite	Landform	Soils	Vegetation
GT1	Till C; blanket	Eutric Brunisol > Regosolic	lodgepole pine forest, mixed coniferous open forest, white spruce open forest
GT2	Till C; blanket, inclined	Northerly: Eutric Brunisol Southerly: Regosolic	Northerly: lodgepole pine forest Southerly: dry grassland, low shrub-herb meadow

Figure 41 Landscape schematic showing the relationship of the Goat (GT1, GT2) Ecosites to other Ecosites.



Orthic Regosols occur on more severely eroded localities where fresh weathering surfaces are maintained. Orthic Humic Regosols and Cumulic Regosols occur in minor amounts in localities where erosional products accumulate.

A pedon illustrating Orthic Regosols of GT1 is described in Table 196 and shown in Color Plate 24. This profile and its associated vegetation occur as a small area in a PR2F tract. Because of map scale limitations, small areas resembling GT1 occur in tracts mapped as Panorama Ridge 2 (PR2). Till at this site is less compact than normal due to the massive slope failure that affected the tract.

Table 196 Pedon (Alberta 1979 No. 68) illustrating Orthic Regosols of the GT1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC REGOSOL. SOIL MAP UNIT: NOTATION: PR2F

LOCATION: MILITARY GRID REF. 11 UNJ 7625 289; NTS MAP AREA 83C 6W.

CLIMATE: 1720 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 8 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=LC9183+VTN=C3W.

SOIL SITE: PARENT MATERIAL 1: COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), COLLUVIAL; PARENT MATERIAL 2: SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL); LANDFORM CLASSIFICATION: MORAINAL, GULLIED AND FAILING, BLANKET; SLOPE: 65% SLOPE OF CLASS 8 (46-70%), FACING WEST, SITE AT MIDDLE POSITION, MODERATELY MOUNDED MICROTOPOGRAPHY,60 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, MODERATELY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; SLIGHTLY ROCKY.

SPECIAL NOTES: SSM=NT9162+APM=015-056+RLU=15+PCF=1GR(1)2AGR.1GR.1CB(2)2GR.2AGR.2CB(2)3GR.2AGR.2CB.2ACB.1ST(4)LFM=CV/MB/WI-V, F=DATE=SEPT.23,1979=SOIL AND VEGETATION REPRESENTS GT1 ECOSITE BUT TOO SMALL TO MAP AS GT1

L: 4 TO 0 CM, RANGE 0 TO 5 CM; MATRIX DRY 10YR 3/1; FEW, COARSE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

BCK: 0 TO 28 CM, RANGE 25 TO 38 CM; MATRIX DRY 10YR 5.5/2, MATRIX MOIST 10YR 5/3; SILT LOAM; VERY WEAK, VERY FINE, SUBANGULAR BLOCKY STRUCTURE; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; FRIABLE, SOFT, NONPLASTIC CONSISTENCE; PLENTIFUL, FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

2CK1: 28 TO 70 CM, RANGE 32 TO 42 CM; MATRIX DRY 10YR 6/2, MATRIX MOIST 10YR 5/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT, NONPLASTIC CONSISTENCE; FEW, FINE AND MEDIUM AND COARSE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

2CK2: 70 TO 125 CM; MATRIX DRY 2.5Y 6/2, MATRIX MOIST 2.5Y 6/3; LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SLIGHTLY HARD, NONPLASTIC CONSISTENCE; FEW, FINE AND MEDIUM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
L	6.3	48.20	
BCK	7.5		74.2
2CK1	7.6		80.2
2CK2	7.8		76.4

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS												
	% PASSING										% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
L														
BCK					8	8	6	6	4	32		53	15	
2CK1					6	8	6	6	3	29		57	14	
2CK2	99	86	59	49	9	14	12	10	4	49		42	9	

PHYSICAL DATA

	ENGINEERING							
HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
L								
BCK								
2CK1								
2CK2	12.0	16.0					24	18

Vegetation

Vegetation development and distribution reflect surface erosional processes, exposure, and southerly aspects. An open forest variant of the lodgepole pine/juniper/bearberry (C3) v.t. and the Engelmann spruce-subalpine fir-white-bark pine-lodgepole pine (O4) and white spruce/juniper/bearberry (O17) v.t.s dominate GT1. The C3 open forest variant is most abundant but a few GT1 tracts are dominated by O4 and O17. The central concept of closed forest C3, lodgepole pine/buffaloberry/showy aster (C6), and lodgepole pine/buffaloberry/twinflower (C19) commonly occupy stable, protected sites on the landscape. White spruce-Douglas fir/feathermoss (C5), Douglas fir/juniper/bearberry (O5) and shrubby cinquefoil/bearberry-northern bedstraw (L1) occur in minor amounts. Modification of the vegetation by avalanching, mapped as GT1A, and by recent fire, mapped as GT1B, has occurred in some areas.

A plot illustrating the C3 open forest variant on GT1 is presented in Table 197 and Plate 114. This plot and its associated soil occur as a small area in a PR2F tract. Because of map scale limitations, small areas resembling GT1 occur in tracts mapped as Panorama Ridge 2 (PR2).

Table 197 Stand (LC9183) illustrating an open variant of the lodgepole pine/juniper/bearberry (C3) v.t. of the GT1 Ecosite.

TREE LAYER	
Pinus contorta	15
TALL SHRUB LAYER	
Pinus contorta	05
SHRUB LAYER	
Juniperus communis	04
Shepherdia canadensis	04
Salix spp.	02
HERB-DWARF SHRUB LAYER	
Arctostaphylos uva-ursi	22
Carex spp.	01
Elymus innovatus	10
Linnaea borealis	03
Pyrola secunda	.5
Rosa acicularis	.5
Solidago spp.	03
Zygadenus elegans	01
BRYOID LAYER	
Cladonia undulatum	.5
Hypnum revolutum	.5
Solorina spongiosa	.5
Xanthoria elegans	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

In terms of landform, GT1 resembles the Panorama Ridge 2 (PR2) Ecosite. The PR2 Ecosite, however, is dominated by Brunisolic and Luvisolic soils occurring under lodgepole pine closed forest, features that indicate significantly less surface erosion. Several tracts mapped as PR2 contain, because of map scale limitations, actively eroding or recently eroded localities that resemble GT1 in terms of soil and vegetation. Similarly, portions of southerly aspect segments of the Panorama Ridge 4 (PR4) Ecosite resemble GT1. The Sawback 4 (SB4) Ecosite displays soils and vegetation similar to GT1 but occurs on very steep, linear, often rocky slopes dominated by veneers and blankets of calcareous, medium textured colluvium (Colluvium C). Slopes consisting of Colluvial material C frequently occur adjacent to and above GT1 tracts. The GT2 Ecosite is differentiated from GT1 by its compound landscape pattern involving pine forest on protected segments and treeless grassland and shrub-herb meadow on steep, exposed, unstable, southerly aspects (Table 195).

GT2 - GOAT 2 ECOSITE

Ecosite Concept

The Lower Subalpine GT2 Ecosite occurs on inclined and ridged morainal landforms consisting of calcareous, medium textured till (Till C). Surface expression reflects the down- and sidecutting activity of streams on valley floors or the underlying bedrock on valley walls and benchlands. Both soils and vegetation are found in a landscape pattern influenced by aspect, steepness of slope, exposure, and erosional processes such as gullying, sheet erosion, and shallow colluviation. On relatively stable, unexposed portions of the landscape ("northerly aspects"), well drained Orthic Eutric Brunisols occur with the mesic lodgepole pine/buffaloberry/twinflower (C19) and lodgepole pine/buffaloberry/showy aster (C6) v.t.s. The C19 v.t. is most abundant. Rapidly drained Orthic Eutric Brunisols and Orthic Humic Regosols with the subxeric hairy wild rye-junegrass-bearberry (H14) and shrubby cinquefoil/bearberry-northern bedstraw (L1) v.t.s dominate the exposed, steeply sloping, eroding, or recently eroded portions of southerly aspects. The H14 v.t. is most abundant on these essentially treeless localities, termed "southerly aspects". While exposed treeless segments are confined to steep southerly aspects, the forested segments occur on northerly aspects, ridge crests, depressions, and stable portions of southerly aspects. A few southerly aspect GT2 tracts are dominated by dry grassland. The GT2 Ecosite is confined to the Front Ranges, usually in association with Mesozoic strata, and is more extensive in Banff than in Jasper.

Geomorphology

The GT2 Ecosite is typified by morainal landforms consisting of calcareous, medium textured till (Till C) and, occasionally, non-calcareous, medium textured till (Till B). Glacial landforms comprised of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) on and adjacent to river banks are also included in the GT2 concept. Veneers of altered, medium textured eolian material (Eolian material B) occur sporadically on stable landscape segments and are absent on eroding and recently eroded southerly aspects. Alternately, erosional products from gullying, sheet erosion, and shallow colluviation have been distributed downslope, resulting in local occurrences of veneers and blankets of calcareous, medium textured colluvium (Colluvium C) and calcareous, coarse, stratified fluvial material (Fluvial material B), Fluvial material B also dominates the fluvial floodplains and terraces included in some tracts mapped as GT2 (Fig. 41).

Topographically, GT2 dislays either linear slopes or irregular, usually ridged surfaces. Two modes of formation are involved. On valley walls and benchlands, the inclined and ridged surfaces generally reflect underlying bedrock (Fig. 41), although deeper, strictly depositional, hummocky and ridged moraines also occur occasionally. The second type displays short, linear, erosional scarps produced by the down and sidecutting action of present and historical streams through the glacial deposits of valley floor benchlands and valley walls. Tracts representing this latter type are generally long, narrow, and sinuous and accommodate one or both stream banks depending on the areal extent of the fluvial landforms separating them. Ravine or canyon-like GT2 tracts include opposing stream erosional scarps plus the narrow fluvial floodplains and terraces that separate them (Fig. 41). On broad floors of major river valleys, the opposing river banks are usually mapped as two separate GT2 tracts when they are separated by wide, mappable, glaciofluvial or fluvial landforms (Fig. 52). Tracts of GT2 encompassing one straight to gently curving streambank have narrow aspect ranges throughout this length, but on sinuous stream banks all aspects can occur.

Slopes of the GT2 Ecosite commonly range from 30 to 90%, with linear ones usually being gullied. The steepest sloping tracts have been subjected to severe downcutting and surface erosion resulting in the exposure of bedrock. Bedrock walls are common on these gorge-like tracts (e.g. Tyrrell Creek in Banff). Ridge crest escarpments are common on GT2+R tracts. Morainal veneers occur occasionally on all types of terrain. Small fluvial fans, aprons, and veneers and colluvial veneers occur locally on eroded slopes.

Soils

Soils of GT2 are distributed in a pattern governed by aspect, steepness of slope, exposure, and erosional processes. Northerly aspects and other relatively stable portions of the landscape are dominated by Orthic Eutric Brunisols. These well drained soils generally have weakly to moderately developed B horizons that frequently display luvisolic tendencies. Genetically related Brunisolic and Orthic Gray Luvisols occur in minor amounts. Eluvial (Ae) horizons are weakly developed or absent, although Orthic Dystric Brunisols occur locally and are correlated with occurrences of noncalcareous, medium textured till (Till B). Eluviated Eutric Brunisols occur as accessory soils. Some exceptionally steep northerly aspects, exhibiting active colluviation locally, have Regosolic soils. Cryosolic soils occur occasionally on steep northerly aspects (e.g. Rock Creek area in Jasper). The pedons described in Table 301 and 305, for the Panorama Ridge 2 and 4 (PR2, PR4) Ecosites respectively, illustrate, except for degree of Ae development, soils of northerly aspect segments of GT2.

Exposed southerly aspects of GT2 are warmer, drier, steeper, and subject to more erosion. Surface erosional processes such as gullying, sheet erosion, and shallow colluviation (soil creep) are or have recently been active on these segments. Consequently, the rapidly drained, southerly aspect soils reflect these conditions and are dominated by Orthic Eutric Brunisols and Orthic Humic Regosols. Orthic Eutric Brunisols are associated with moderately eroded localities where removal is or has been more important than accretion. These soils generally have weakly developed Bmk or Bm horizons. Eluvial (Ae) horizons are absent but thin Ah horizons are common. Orthic Melanic Brunisols occur occasionally. On some GT2 tracts where the grassland vegetation has, in part, resulted from severe, recent fires (e.g. lower Tyrrell Creek valley), moderately developed Brunisolic soils (Bm and Btj horizons) dominate. Orthic Humic Regosols occur on more severely eroded localities where accretion is relatively important. They have thick Ahk horizons physically built up by the accumulation of organo-mineral erosional products. Orthic Regosols, occurring as accessory soils, may have thin Ah horizons and are generally associated with sites where removal is more dominant than accretion. Cumulic Humic Regosols also occur occasionally. A pedon illustrating Orthic Humic Regosols of exposed, unstable, southerly aspects of GT2 is described in Table 198 and shown in Color Plate 25.

Vegetation

Vegetation of GT2 is distributed in a pattern governed by aspect, steepness of slope, expo-

Table 198 Pedon (Alberta 1979 No. 84) description of an Orthic Humic Regosol of southerly aspect segments of the GT2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC HUMIC REGOSOL. SOIL MAP UNIT: NOTATION: GT2.

LOCATION: MILITARY GRID REF. 11 UNH 8155 2685; NTS MAP AREA 82O 12H.

CLIMATE: 2080 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 12 DEG(C) AT 50 CM IN AUGUST.

VE'ETATION: VPN=JD9075*VTN=L1*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), COLLUVIAL, SEDIMENTARY; PARENT MATERIAL 2: COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL); LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 53% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING SOUTH, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,100 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY.

SPECIAL NOTES: SSN=NT9143*APH=015-100*RLU=15*PCF=1AGR,1GR(1)2AGR,1GR(2)2ACB,1CB,1CB,4AGR,3GR(3-5)1ST,2CB,1ACB,3GR,2AG(6) *LFH=CV/MB/RI*AHK1 HORIZON IS TURFY*THICK CARBONATE COATINGS UNDER COARSE FRAGS IN CK2*DATE=AUG.24,1979*

L: 3 TO 0 CM, RANGE 2 TO 4 CM; MATRIX MOIST 10YR 2/1; VERY FEW, COARSE ROOTS; INTERSTITIAL PORES; WAVY, CLEAR HORIZON BOUNDARY.

AHK1: 0 TO 11 CM, RANGE 10 TO 12 CM; MATRIX MOIST 10YR 3/1; COARSE SANDY LOAM; ABUNDANT, MICRO AND VERY FINE AND FINE AND MEDIUM AND COARSE ROOTS; INTERSTITIAL PORES; WEAK EFFERVESCENCE; STRONGLY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

AHK2: 11 TO 43 CM, RANGE 30 TO 35 CM; MATRIX DRY 10YR 3/1.5; COARSE SANDY LOAM; MASSIVE STRUCTURE; SLIGHTLY HARD CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE AND MEDIUM AND COARSE ROOTS; INTERSTITIAL PORES; STRONG EFFERVESCENCE; STRONGLY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CK1: 43 TO 51 CM, RANGE 5 TO 10 CM; MATRIX DRY 7.5YR 5/3; COARSE SANDY LOAM; MASSIVE STRUCTURE; SLIGHTLY HARD CONSISTENCE; FEW, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; INTERSTITIAL PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CK2: 51 TO 74 CM, RANGE 20 TO 23 CM; MATRIX DRY 10YR 6/3; LOAM; MASSIVE STRUCTURE; HARD CONSISTENCE; FEW, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; INTERSTITIAL PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

2CK: 74 TO 121 CM, RANGE 25 CM; MATRIX DRY 10YR 7/2; LOAM; MASSIVE STRUCTURE; VERY HARD CONSISTENCE; VERY FEW, MICRO AND VERY FINE AND FINE ROOTS; INTERSTITIAL PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1 :	ORG C (%)	CALC CARB EQU.%
L	6.5	26.80	
AHK1	7.2	15.60	19.9
AHK2	7.4	6.00	20.3
CK1	7.5	3.10	52.8
CK2	7.5	1.80	69.2
2CK	7.8	0.00	74.9

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS													
	% PASSING										% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
L														
AHK1					3	29	18	9	5	65		25	10	
AHK2					19	19	10	7	8	63		27	10	
CK1					17	15	8	6	7	53		37	10	
CK2					13	11	9	8	8	49		38	13	
2CK	99	69	49	42	8	9	8	10	10	45		39	16	

PHYSICAL DATA

	ENGINEERING						
HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
L								
AHK1								
AHK2								
CK1								
CK2								
2CK	13.0	23.0		11.0	1.8		24	03

sure, and erosional processes. In some areas, recent and severe burning has also been a factor. Northerly aspects and other relatively stable, unexposed portions of the landscape are dominated by the mesic lodgepole pine/buffaloberry/showy aster (C6) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s. The C19 v.t. is most abundant but C6 dominates northerly aspects of a few GT2 tracts. The closely related lodgepole pine/buffaloberry/grouseberry (C18) v.t. occurs in minor amounts. A few GT2 tracts (e.g. Panther River valley east of the Bare Range in Banff) have spruce forest best represented by the Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica/twinflower/feathermoss (C31) v.t., on northerly aspects. Engelmann spruce-subalpine fir/feathermoss (C13) also occurs occasionally. Modification of forest vegetation by avalanching, mapped as GT2A, and recent fire, mapped as GT2B has occurred in some areas.

Exposed, unstable portions of southerly aspects are dominated by the subxeric hairy wild rye-junegrass-bearberry (H14) and shrubby cinquefoil/bearberry-northern bedstraw (L1) v.t.s. The H14 v.t. is the most abundant but some exposed southerly aspect segments are dominated by L1. White spruce/juniper/bearberry (O17) is an important accessory v.t. on some localities. Junegrass-pasture sage-wild blue flax (H6), wheatgrass-pasture sage (H7), and aspen/hairy wild rye-showy aster (C22) occur in minor amounts. A plot representing vegetation of the pedon sample site described above (Table 198) and illustrating L1 on exposed southerly aspects of GT2 is presented in Table 199 and Plate 115.

Table 199 Stand (JD9075) illustrating the shrubby cinquefoil/bearberry-northern bedstraw (L1) v.t. of southerly aspect segments of the GT2 Ecosite.

SHRUB LAYER	
Juniperus horizontalis	10
Shepherdia canadensis	01
HERB-DWARF SHRUB LAYER	
Androsace chamaejasme	.5
Androsace septentrionalis	.5
Anemone multifida	02
Arctostaphylos uva-ursi	50
Aster alpinus	.5
Aster hesperius	.5
Bromus pumpellianus	05
Campanula rotundifolia	.5
Carex rupestris	01
Cerastium arvense	.5
Draba lanceolata	.5
Elymus innovatus	15
Festuca saximontana	.5
Gaillardia aristata	.5
Galium boreale	.5
Gentiana propinqua	02
Hedysarum mackenzii	05
Koeleria cristata	05
Oxytropis campestris	.5
Poa palustris	05
Potentilla fruticosa	05
Rhinanthus crista-galli	.5
Senecio canus	.5
Solidago decumbens	.5
Trisetum spicatum	03
BRYOID LAYER	
Tortula ruralis	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The Engelmann spruce-subalpine fir/willow/hairy wild rye (O18) and lodgepole pine/juniper/bearberry (C3) v.t.s occur sporadically, in minor amounts, on either segment of GT2. The O18 v.t. is associated with erosional slopes of both northerly and southerly aspects. The C3 v.t. occurs occasionally on ridge crests and other, relatively unexposed, stable sites. An open forest variant of C3 occurs ocassionally on the steep, exposed, southerly aspect, landscape segments.

A few GT2 tracts located on lower valley walls and benchlands (e.g. lower Tyrrell Creek valley in Banff) are dominated by the grassland (H14) segment and have only isolated patches of pine forest. Erosion on these tracts is not significant and Orthic Eutric Brunisols dominate. These features and their extensive distribution on such tracts is attributed to severe and recent (<100 years) fire. Slope, aspect, and exposure are helping maintain the grassland vegetation from succeeding to pine forest.

Discussion

The Lower Subalpine GT2 Ecosite is distinguished from similar Ecosites by a compound landscape pattern comprised of steep, exposed southerly aspects (resembling the Upper Subalpine TR2 and the Lower Subalpine SB5 Ecosites) and relatively unexposed, stable, northerly aspects (resembling the PR2 Ecosite). Map presentation of GT2 tracts at scales larger than 1:50,000 is invalid because the component segments would become mappable as separate Ecosites. Overall, GT2 resembles the Norquay 3 (NY3) Ecosite but NY3 occurs in the Montane Ecoregion. Also, PR4, like GT2, is a Lower Subalpine Ecosite but is characterized by spruce-fir forests on northerly aspects and lodgepole pine forests on southerly aspects, whereas GT2 is typified by lodgepole pine forests on northerly aspects and by grassland and low shrub-herb meadow on southerly aspects. The GT1 Ecosite is differentiated from GT2 by linear slopes and open forest vegetation in the former (Table 195).

HC - HECTOR ECOSECTION

The Hector Ecosection is complex and encompasses wet fluvial and fluviolacustrine landforms throughout the Lower Subalpine portion of the Subalpine Ecoregion in Banff and Jas-

per. Level plains, aprons, and fans are characteristic of Hector Ecosites. These landforms consist of calcareous, coarse, stratified fluvial material (Fluvial material B), occasionally noncalcareous, coarse, stratified fluvial material (Fluvial material A), and calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B). The subdominant landform on some HC Ecosites consists of horizontal fens that thinly mantle the fluvial and fluviolacustrine materials on the wettest localities.

A complex set of genetically related Gleysolic, gleyed Regosolic, and Organic soils is characteristic, with the Gleysolic soils being dominant. Distribution of these soils is related to degrees of gleying and saturation and the frequency of material accretion by flooding. Various groupings of Engelmann spruce forest, Engelmann spruce-subalpine fir open forest, wet shrubby meadow, birch fen, wet shrub thicket, and sedge fen differentiate the three HC Ecosites as outlined in Table 200.

The HC Ecosection most often occurs on valley floors adjacent to creeks and rivers. Attendant high water tables account, in the main, for its wetness. Hector 1 and 4 (HC1, HC4) are shown, schematically, on valley floor and benchland positions in Figs. 33, 37, 40, and 52. The HC2 Ecosite occupies similar valley floor positions. Plates 116 and 117 show HC2 and HC4 tracts on the landscape. A few tracts occur on valley floor benchlands in groundwater discharge zones where surface accumulations and seepage contribute to the wet conditions. In eastern Banff and Jasper, HC1 and HC4 often occur on benchlands below Snowflake 1 (SF1) tracts.

HC1 - HECTOR 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, HC1, encompasses wet fluvial landforms dominated by forest vegetation. These landforms consist primarily of calcareous, coarse, stratified fluvial material (Fluvial material B) and occasionally of noncalcareous, coarse, stratified fluvial material (Fluvial material A). Surface expressions include level floodplains, aprons and fans. Many surfaces are channeled (Eroded modifier, C.S.S.C. 1978b). The subdominant landform consists of horizontal fens that thinly mantle the fluvial materials on ponded localities.

A complex set of genetically related soils, reflecting recently deposited parent material and varying degrees of gleying, saturation and organic matter accumulation, characterizes the HC1 Ecosite. These soils are best represented by a soil pattern in which Rego Gleysols are dominant and Gleyed Cumulic Regosols and Terric Mesisols are subdominant. Vegetation is also complex and is best represented by a pattern in which the Engelmann spruce/horsetail/feathermoss (C32) and Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6) v.t.s are dominant and the dwarf birch-shrubby cinquefoil-willow/brown moss (S1) and dwarf birch-shrubby cinquefoil/needlerush (S3) v.t.s are subdominant.

Geomorphology

The HC1 Ecosite is typified by fluvial landforms consisting primarily of calcareous, coarse, stratified fluvial material (Fluvial material B). A few tracts are dominated by noncalcareous, coarse, stratified fluvial material (Fluvial material A). Weakly calcareous mixtures of the two fluvial deposits occur often. Glaciofluvial material, mainly calcareous, coarse textured glaciofluvial material (Glaciofluvial material B), occurs on tracts associated with glacial streams. Important accessory genetic materials, occurring as veneers or layers on or within the fluvial deposits, are calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) and, occasionally, altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A). The fluviolacustrine materials occur on what were backwater depositional localities on floodplains and as veneers on the

Table 200 General features of the Hector (HC) Ecosites.

Ecosite	Landform	Soils	Vegetation
HC1	Fluvial material A,B; level, apron, fan > horizontal fen	Gleysol > gleyed Regosol, Organic	moist Engelmann spruce forest, wet Engelmann spruce-subalpine fir forest > wet shrubby meadow, birch fen
HC2	Fluviolacustrine material B; level	Gleysol	sedge fen
HC4	Fluvial material A,B; level, apron, fan > horizontal fen	Gleysol > gleyed Regosol, Organic	wet shrubby meadow, birch fen, wet shrub thicket, sedge fen

fringes of fans and aprons. Organic soils frequently overlie fluviolacustrine material, both features indicating ponding by currentless, relatively stagnant water. The fluvial and fluviolacustrine deposits may contain reworked material originally deposited as altered, medium textured eolian material (Eolian material B). Various tills underlie the fluvial deposits at shallow depths on some localities. Small morainal outcrops occur sporadically.

Soils of the HC1 Ecosite are usually thinly mantled by peat derived primarily from sedges and brown mosses (e.g. *Tomenthypnum nitens* and *Aulacomnium palustre*). This fen peat, rarely exceeding 1.2 m in thickness, is mainly moderately decomposed but fibric and humic layers also occur. Occasionally wood fragments may be found. Where the peat is >40 cm thick, the landform is classified as horizontal fen (C.S.S.C. 1978b) recognizing that in some localities fen vegetation has been succeeded by open forest. The fen peat is underlain, within the control section, by the fluvial and fluviolacustrine deposits. On some sites Eolian material B containing volcanic ash is preserved in thin layers at or near the base of organic deposits.

Topographically, HC1 displays gentle linear slopes on level floodplains, aprons, and fans. Slopes commonly range from 0 to 9%. Tracts with complex slopes have irregular surfaces reflecting, in part, underlying morainal landforms. Slope continuity is often broken by abandoned and active stream channels, including their natural levee borders (Eroded modifier, C.S.S.C. 1978b). Weakly expressed terracing (risers <1 m) is a minor feature on some floodplain tracts.

Soils

Soils of the HC1 Ecosite are complex and reflect recently deposited parent material and varying degrees of gleying, saturation, and organic matter accumulation. These imperfectly, poorly, and very poorly drained soils are best represented by a pattern in which Rego Gleysols are dominant and Gleyed Cumulic Regosols and Terric Mesisols are subdominant. The strength of gleying is variable and reflects varying degrees of water table fluctuation, lateral water movement, and seepage water aeration. Prolonged periods of saturation give strongly gleyed soils with little or no pedogenic horizonation (Rego Gleysols). Gleyed Cumulic Regosols and the accessory soils, Gleyed Regosols, Gleyed Eutric Brunisols, and Orthic Gleysols, occur where saturation periods are shorter and depth to the water table is greater. Pedogenic horizonation in the Regosolic soils is limited by active or recently active fluvial deposition. The Gleyed Eutric Brunisols and Orthic Gleysols occur on the oldest surfaces where sufficient time for B horizon development has elapsed. Favorable moisture, nutrient, and vegetation conditions have resulted in the accumulation of varying thicknesses of fen peat on most HC1 soils. Terric Mesisols occur where the peat is >40 cm thick. Other soils with subdominant humic or fibric layers and Humic Gleysols occur occasionally. Well to moderately well drained Brunisolic and Regosolic soils occupy sites where the fluctuating water table rarely reaches the control section. A pedon illustrating Rego Gleysols of HC1 is described in Table 201 and shown in Color Plate 26.

Vegetation

Vegetation of the HC1 Ecosite is complex and is best represented by a pattern in which the Engelmann spruce/horsetail/feathermoss (C32) and Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6) v.t.s are dominant and the dwarf birch-shrubby cinquefoil-willow/brown moss (S1) and dwarf birch-shrubby cinquefoil/needlerush (S3) v.t.s are subdominant. Generally associated with C32 are imperfectly to poorly drained soils, mainly Gleysols, gleyed Regosols, and gleyed Brunisols, that display comparatively dry surface conditions. Organic soil and C32 do not occur together. Vegetation types O6, S1, and S3 are associated with soils that are saturated to the surface. The S1 and S3 v.t.s. break up the closed to open forest continuity by occurring frequently in small patches. Their areal extent is low. A plot representing vegetation of the pedon sample site (Table 201) is presented in Table 202 and Plate 118.

Spruce/Labrador tea/brown moss (O11) and water sedge-beaked sedge (H11) are accessory v.t.s occurring on poorly to very poorly drained soils. The O11 v.t. is restricted to relatively low elevations (<1800 m) and is more abundant in Jasper. The H11 v.t. occurs in small patches on very poorly drained, ponded, level sites. Other accessory v.t.s include Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/willow/hairy wild rye (O18) that are associated with imperfectly to well drained soils on localities where water table fluctuations only occasionally affect the control section. Black spruce-lodgepole pine/willow/sedge (C8), white spruce/buffaloberry/fern moss (C26), lodgepole pine/Labrador tea (C29), Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30), white spruce/shrubby cinquefoil/bearberry (O3), Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14), willow/cinquefoil (S8), sedge-saxifrage (H3), and yellow dryad-willow herb (H8) are v.t.s occurring in minor amounts on HC1. Modification of HC1 vegetation by avalanching (e.g. areas mapped as HC1A in Forty Mile Creek valley in Banff) and by recent fire (e.g. areas mapped as HC1B in Molar Creek valley in Banff) occur infrequently.

Table 201 Pedon (Alberta 1978 No. 68) description of a Rego Gleysol of the HC1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: REGO GLEYSOL. SOIL MAP UNIT: NOTATION: HC1.

LOCATION: MILITARY GRID REF. 11 UNG 7930 7180; NTS MAP AREA 82O 4W.

CLIMATE: 1660 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JE8133*VTN=C32*..

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, SANDY AND STRATIFIED (MINERAL), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), FLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: FLUVIAL, EPODED(CHANNELLED), LEVEL; SLOPE: 1% SIMPLE SLOPE OF CLASS 2 (0.5-2%), SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,200 M LONG; SOIL MOISTURE AND DRAINAGE: POORLY DRAINED, MODERATELY PERVIOUS, VERY SLOW SURFACE RUNOFF, SEEPAGE ABSENT, 0.8 M TO APPARENT WATERTABLE; SLIGHTLY STONY; NONROCKY.

SPECIAL NOTES: SSN=WT8125*APN=783-074*PLU=15*PCF=4GR.1CB(7)4GP,2CN.2CB(8)4GP.2CN.2CB(8)4GR.1CB(9)*LFM=FL(-E)*CKG1 DEVELOPED IN FLUVIOLACUSTRINE VENEER*REDDISH COLOR OF CKG5 RELATED TO WATER TABLE FLUCTUATIONS

OF: 19 TO 11 CM, RANGE 6 TO 10 CM; MATRIX MOIST 7.5YR 4/4; FEW, FINE AND MEDIUM HORIZONTAL ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

OM: 11 TO 0 CM, RANGE 10 TO 12 CM; MATRIX MOIST 10YR 2/1; PLENTIFUL, FINE AND MEDIUM AND COARSE, HORIZONTAL ROOTS; MODERATELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CKG1: 0 TO 5 CM, RANGE 4 TO 6 CM; MATRIX MOIST 10YR 5/3; SILT; COMMON, MEDIUM, PROMINENT, 7.5YR 5/6 MOTTLES; MODERATE, MEDIUM, PLATY STRUCTURE PSEUDO; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, FINE, HORIZONTAL ROOTS; SLIGHTLY POROUS; WEAK EFFERVESCENCE; MODERATELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

OMB: 5 TO 9 CM, RANGE 3 TO 6 CM; MATRIX MOIST 10YR 2/1; SILT LOAM; FEW, FINE AND MEDIUM, HORIZONTAL ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

CKG2: 9 TO 18 CM, RANGE 8 TO 12 CM; MATRIX MOIST 10YR 5/3; SILT LOAM; COMMON, MEDIUM, PROMINENT, 7.5YR 5/6 MOTTLES; MODERATE, MEDIUM, PLATY STRUCTURE PSEUDO; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, FINE, HORIZONTAL ROOTS; SLIGHTLY POROUS; WEAK EFFERVESCENCE; MODERATELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CKG3: 18 TO 32 CM, RANGE 10 TO 15 CM; MATRIX MOIST 10YR 5/2; FINE SANDY LOAM; COMMON, MEDIUM, PROMINENT, 7.5YR 5/6 MOTTLES; VERY WEAK, COARSE, PLATY STRUCTURE PSEUDO; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, FINE, HORIZONTAL ROOTS; MODERATELY POROUS; WEAK EFFERVESCENCE; MODERATELY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

CKG4: 32 TO 58 CM, RANGE 23 TO 27 CM; MATRIX MOIST 10YR 6/3; GRAVELLY LOAMY COARSE SAND; FEW, MEDIUM, PROMINENT, 7.5YR 5/6 MOTTLES; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; VERY FEW, FINE, HORIZONTAL ROOTS; MODERATELY POROUS; WEAK EFFERVESCENCE; MODERATELY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CKG5: 58 TO 79 CM; MATRIX MOIST 7.5YR 5/6; GRAVELLY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; VERY FEW, FINE, HORIZONTAL ROOTS; MODERATELY POROUS; WEAK EFFERVESCENCE; MODERATELY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CKG6: 79 TO 90 CM; MATRIX MOIST 10YR 5/3; GRAVELLY LOAMY COARSE SAND; 7.5YR 5/6 MOTTLES, STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; VERY FEW, FINE, HORIZONTAL ROOTS; MODERATELY POROUS; WEAK EFFERVESCENCE; MODERATELY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PEPM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
OF	5.1	45.80							
OM	6.2	37.90							
CKG1	6.9	0.90	7.3						
OMB	6.6	24.00	0.5	208.7		122.3	33.6	0.1	0.3
CKG2	7.1	0.90	17.5						
CKG3	7.2	0.70	10.7						
CKG4	7.4	2.30	17.4						
CKG5	7.1	0.30	12.2						
CKG6	7.4	0.70	18.9						

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
OF														
OM														
CKG1										3		86	11	
OMB										6		75	19	
CKG2	99	99	99	99			1	13	17	31		65	14	
CKG3					1	2	8	26	16	53		38	9	
CKG4					10	27	22	10	5	74		25	1	
CKG5					10	15	11	7	5	48		41	11	
CKG6					19	20	13	16	7	75		22	3	

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
OF								
OM								
CKG1								
OMB								
CKG2	26.0	31.0					40	09
CKG3								
CKG4								
CKG5								
CKG6								

Table 202 Stand (JE8133) illustrating the Engelmann spruce/ horsetail/ feathermoss (C32) v.t. of the HC1 Ecosite.

TREE LAYER	
Abies lasiocarpa	14
Picea glauca	21
TALL SHRUB LAYER	
Abies lasiocarpa	01
Picea glauca	02
SHRUB LAYER	
Abies lasiocarpa	01
Ledum glandulosum	.5
Menziesia glabella	01
Picea glauca	01
Rosa acicularis	.5
Salix glauca	05
HERB-DWARF SHRUB LAYER	
Astragalus frigidus	.5
Carex spp.	.5
Cornus canadensis	02
Elymus innovatus	.5
Empetrum nigrum	.5
Juniperus communis	.5
Linnaea borealis	01
Lonicera involucrata	.5
Mitella nuda	.5
Moneses uniflora	.5
Petasites palmatus	.5
Petasites vitifolius	01
Pyrola secunda	.5
Rubus acaulis	.5
Vaccinium caespitosum	.5
Vaccinium scoparium	01
Equisetum arvense	10
Equisetum pratense	05
Equisetum scirpoides	01
BRYOID LAYER	
Aulacomnium palustre	01
Cladonia cenotea	.5
Cladonia chlorophaea	.5
Cladonia coniocraea	.5
Cladonia ecmocyna	.5
Cladonia gonecha	.5
Cladonia pyxidata	.5
Cyphelium inquinans	.5
Dicranum fuscescens	.5
Dicranum polysetum	.5
Dicranum scoparium	01
Ditrichum flexicaule	.5
Drepanocladus uncinatus	.5
Hylocomium splendens	35
Icmadophila ericetorum	.5
Mnium pseudopunctatum	.5
Peltigera aphthosa	.5
Peltigera canina	.5
Peltigera malacea	.5
Pleurozium schreberi	30
Psoroma hypnorum	.5
Ptilidium pulcherrimum	.5
Ptilium crista-castrensis	.5
Sphagnum capillaceum	.5
Tetraphis pellucida	.5
Tortella fragilis	.5
EPIPHYTES	
Alectoria sarmentosa	.5
Bryoria fremontii	.5
Calicium abietinum	.5
Candellaria concolor	.5
Candellariella xanthostigma	.5
Cetraria ericetorum	.5
Cetraria pinastri	.5
Hypogymnia physodes	.5
Lecanora impudens	.5
Lecidea spp.	.5
Lepraria spp.	.5
Letharia vulpina	.5
Parmelia exasperatula	.5
Parmelia sulcata	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The HC1 Ecosite is broad in concept and encompasses wet fluvial terrain dominated by closed to open spruce forest in the Lower Subalpine. The Vermilion Lakes 3 and 4 (VL3, VL4) Ecosites resemble and are the Montane counterparts of HC1 but have different v.t.s, relating to the Ecoregion in which they occur. There is no Upper Subalpine counterpart of HC1. The wet segments of the Baker Creek 1, 4, and 6 (BK1, BK4, BK6), Cavell 1 (CA1), Consolation Valley 1 (CV1), Topaz 2 (TZ2), and Merlin Castle 1 (MC1) Ecosites sometimes resemble HC1, but are too small to be delineated as HC1 at a mapping scale of 1:50,000. Also, conceptually these Ecosites have a compound dry > wet or wet > dry landscape pattern and different landforms with attendant differences in soil and vegetation which serve to distinguish them from HC1. The HC4 Ecosite is differentiated from HC1 by its shrub dominated vegetation. The HC2 Ecosite is differentiated by its active fluviolacustrine deposition influencing soil and vegetation (Table 200).

HC2 - HECTOR 2 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite HC2 is characterized by wet fluviolacustrine floodplains dominated by sedge fen vegetation. These level floodplains consist of calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) and are associated with glacial streams near the Continental Divide in Banff and Jasper. The floodplain surfaces are usually eroded (channeled). Pools, ponds, and small lakes are abundant on some HC2 tracts.

Very poorly drained Rego Gleysols lacking organic surface layers are dominant and reflect active accretion by siltation from ponded, silt-laden streams. Vegetation of the HC2 Ecosite also refelcts siltation and is dominated by a bryoid-poor variant of the water sedge-beaked sedge (H11) v.t.

Table 203 Pedon (Alberta 1978 No. 90) description of a Rego Gleysol of the HC2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: REGO GLEYSOL. SOIL MAP UNIT: NOTATION: HC2.

LOCATION: MILITARY GRID REF. 11 UNH 3170 3270; NTS MAP AREA 82N 10E.

CLIMATE: 1790 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 3 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JC8083+VTH=H11+..

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY) AND STRATIFIED (MINERAL AND ORGANIC), EXTREMELY CALCAREOUS (>40% CACO3), FLUVIOLACUSTRINE; LANDFORM CLASSIFICATION: FLUVIAL AND LACUSTRINE, LEVEL; SLOPE: 0% SIMPLE SLOPE OF CLASS 1 (0-0.5%), FACING LEVEL, SITE AT MIDDLE POSITION, LEVEL MICROTOPOGRAPHY,700 M LONG; SOIL MOISTURE AND DRAINAGE: VERY POORLY DRAINED, SLOWLY PERVIOUS, FORDED SURFACE RUNOFF, SEEPAGE ABSENT, 0 M TO APPARENT WATERTABLE; NONSTONY; NONROCKY; PRESENT LAND USE: OUTDOOR RECREATION, FEN.

SPECIAL NOTES: SSN=BW8135+APN=703-90+RLU=15+HORIZON 3(C+02) IS FIBRIC MATERIAL WITH IN-WASHED CALCAREOUS SILT AND CLAY+OTHER C+O HORIZONS ARE DOMINANTLY CALCAREOUS SILT AND CLAY WITH THIN LAYERS AND POCKETS OF FIBRIC ORGANIC MATERIALS+SILTY CALCAREOUS MATERIAL ON SOIL SURFACE

C+O1: 0 TO 15 CM, RANGE 13 TO 17 CM; NATURAL WET/REDUCED 5Y 5/1; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SLIGHTLY STICKY, SLIGHTLY PLASTIC CONSISTENCE; ABUNDANT, VERY FINE AND FINE ROOTS; MODERATE EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CKG1: 15 TO 32 CM, RANGE 15 TO 21 CM; NATURAL WET/REDUCED 5Y 6/1; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; STICKY, SLIGHTLY PLASTIC CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; MODERATE EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

C+O2: 32 TO 40 CM, RANGE 6 TO 11 CM; NATURAL WET/REDUCED 10YR 2/2, 5Y 4/1; PLENTIFUL, VERY FINE AND FINE ROOTS; MODERATE EFFERVESCENCE; VERY STRONGLY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

C+O3: 40 TO 59 CM, RANGE 17 TO 21 CM; NATURAL WET/REDUCED 5Y 6/1; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SLIGHTLY STICKY, SLIGHTLY PLASTIC CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; MODERATE EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

CKG2: 59 TO 66 CM, RANGE 6 TO 9 CM; NATURAL WET/REDUCED 5Y 6/1; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; STICKY, SLIGHTLY PLASTIC CONSISTENCE; FEW, VERY FINE ROOTS; MODERATE EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

C+O4: 66 TO 70 CM; NATURAL WET/REDUCED 5Y 4/1; SILTY CLAY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SLIGHTLY STICKY, SLIGHTLY PLASTIC CONSISTENCE; FEW, VERY FINE ROOTS; MODERATE EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
C+O1	7.6	0.20	62.3
CKG1	7.6	0.00	69.5
C+O2	7.4	6.40	35.2
C+O3	7.5	1.80	66.2
CKG2	7.6	0.30	73.7
C+O4	7.4	4.40	45.8

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS													
	% PASSING										% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	80-2U SILT	2U CLAY	0.2U CLAY
C+O1												81	19	
CKG1												84	16	
C+O2														
C+O3												83	17	
CKG2		99	99	99	99							81	19	
C+O4												71	29	

PHYSICAL DATA

	MOISTURE STATUS (%)								ENGINEERING				
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
C+O1													
CKG1		29.4	6.2										
C+O2													
C+O3													
CKG2		28.0	6.5			18.0	28.0		17.0	1.7		40	10
C+O4													

Geomorphology

The HC2 Ecosite is typified by level fluviolacustrine floodplains consisting of calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B). Ponding of silt-laden glacial streams on lakehead deltas and behind river channel constrictions (natural dams) promotes aggradation by siltation. The deltaic floodplain at the head of upper Waterfowl Lake in Banff (Plate 11b) is an example of delta-like HC2 tracts. Other examples are the gravelly fluvial fans of the upper North Saskatchewan River (a PP4+SC tract) and Rampart Creed (a PP3 tract) that have constricted flow of the Alexandra and North Saskatchewan Rivers in Banff, respectively, to the extent that backwater floodplains have been formed upstream from the constrictions (Smith 1972). Areas mapped as HC2 are exemplified by these documented channel constrictions which provide a geomorphic setting for the deposition of fluviolacustrine silts and clays with incorporated organic material occurring as thin, fibrous, silt- and clay-laden layers and pockets. Depth of fluviolacustrine plus organic material is unknown, although Smith (1972) reports up to 7.5 m of material. Underlying material is probably glaciofluvial gravels and sands on constricted river floodplains, glaciolacustrine clays and silts on lakehead deltas. A few small lakes have been filled in by fluvial and fluviolacustrine materials. The very poorly drained portion of what was once a small lake, in the tributary valley immediately north of Peyto Lake in Banff, provides the geomorphic setting for a tract mapped as HC2.

Topographically, HC2 displays linear slopes ranging from 0 to 1%. Slope continuity is broken by numerous active stream channels meandering across the landscape. These channels contain the numerous distributaries of the main stream. Narrow, slightly elevated levees frequently border the channels. Excepting the levees, HC2 is usually inundated with water. Pools, ponds, and small lakes are abundant on some HC2 tracts.

Soils

Rego Gleysols dominate the HC2 Ecosite. These very poorly drained soils reflect ponding and active siltation. Prolonged periods of saturation plus active aggradation inhibit soil development other than strong mottling and gleying. Soils of the HC2 Ecosite lack the surface organic layers (peaty phases) common to soils of other wet Ecosites. On a few tracts (e.g. Dolomite Creek valley in Banff) Rego Gleysols with thin, calcareous, silt-bearing, organic horizons at the surface indicate that the inundating waters do not have a heavy sediment load. These features are transitional to HC4. A pedon illustrating Rego Gleysols of HC2 is described in Table 203 and shown in Plate 119. The sample site and vegetation are shown in Plates 120 and 121.

Vegetation

A bryoid-poor variant of the water sedge-beaked sedge (H11) v.t. dominates HC2 and reflects active siltation from silt-laden glacial meltwater. *Carex physocarpa* is often dominant or codominant with *Carex aquatilis* and *Carex rostrata* on this H11 variant. *Salix brachycarpa* occurs frequently but with low cover. Moss cover is low. Willow/horsetail (S7) occurs as an accessory v.t. on the natural levees bordering distributary streams. Sedge-saxifrage (H3) occurs in small amounts on stream channel borders. Unvegetated portions may occur and account for 50% or more of tracts mapped as HC2+SC (e.g. Dolomite Creek in Banff). A vegetation plot illustrating the bryoid-poor variant of H11 on HC2 is presented in Table 204.

Table 204 Stand (JD7051) illustrating a bryoid-poor variant of the water sedge-beaked sedge (H11) v.t. of the HC2 Ecosite.

SHRUB LAYER	
Salix brachycarpa	.5
HERB-DWARF SHRUB LAYER	
Aster spp.	.5
Carex capillaris	30
Carex flava	.5
Carex physocarpa	30
Carex rostrata	25
Castilleja occidentalis	.5
Deschampsia caespitosa	05
Habenaria dilatata	.5
Juncus alpinus	03
Parnassia parviflora	.5
Pedicularis groenlandica	.5
Tofieldia glutinosa	.5
Triglochin maritima	.5
Equisetum pratense	.5
Equisetum variegatum	.5
BRYOID LAYER	
Catoscopium nigritum	.5
Drepanocladus revolvens	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

The HC2 Ecosite is the least extensive of the Hector Ecosites and, overall, is of small areal extent. It encompasses inundated, actively aggrading, fluviolacustrine floodplains with sedge fen vegetation, features that differentiate it from HC1 and HC4 (Table 200). The Vermilion Lakes 1 (VL1) and Num-Ti-Jah (NT3) Ecosites are the Montane and Upper Subalpine counterparts, respective-

ly, of HC2. Further, VL1 and NT3 occur on fluviolacustrine landforms but include geomorphically inactive floodplains where organic materials are accumulating on the surface. Consequently, VL1 and NT3 have Organic soils besides the Rego Gleysols.

HC4 - HECTOR 4 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, HC4, encompasses wet fluvial landforms dominated by shrubby vegetation. These landforms consist primarily of calcareous, coarse, stratified fluvial material (Fluvial material B), occasionally of noncalcareous, coarse, stratified fluvial material (Fluvial material A). Surface expressions include level floodplains, aprons, and fans. Many surfaces are eroded (channeled). The subdominant landform consists of horizontal fens that thinly mantle the fluvial materials on ponded localities.

A complex set of genetically related soils, reflecting recently deposited parent material and varying degrees of gleying, saturation, and organic matter accumulation, characterizes the HC4 Ecosite. These soils are best represented by a soil pattern in which Rego Gleysols are dominant and Gleyed Cumulic Regosols and Terric Mesisols are subdominant. Vegetation is also complex and is best represented by the dwarf birch-shrubby cinquefoil-willow/brown moss (S1), dwarf birch-shrubby cinquefoil/needlerush (S3), willow/timber oatgrass (S11), and water sedge-beaked sedge (H11) v.t.s. The S1 v.t. is most abundant.

Geomorphology

The HC4 Ecosite is typified by fluvial landforms consisting primarily of calcareous, coarse, stratified fluvial material (Fluvial material B). A few tracts are dominated by noncalcareous, coarse, stratified fluvial material (Fluvial material A). Weakly calcareous mixtures of the two fluvial deposits occur often. Calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) occurs on tracts associated with glacial streams (e.g. along the Glacier River in Banff). Important accessory genetic materials, occurring as veneers on or as layers within the fluvial deposits, are calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) and, occasionally, altered, fine, stratified gluviolscustrine material (Fluviolacustrine material A). The fluviolacustrine materials occur on what were backwater depositional localities of floodplains and as veneers on the fringes of aprons and fans. Organic soils frequently overlie fluviolacustrine material, both features indicating ponding by currentless, relatively stagnant water. The fluvial and fluviolacustrine deposits may contain reworked material originally deposited as altered, medium textured eolian material (Eolian material B). Various tills underlie the fluvial deposits at shallow depths on some localities.

Ecosites mapped as HC4 are usually mantled by thin peat deposits derived primarily from sedges and brown mosses (e.g. *Tomenthypnum nitens* and *Aulacomnium palustre*). This fen peat, rarely exceeding 1.2 m in thickness, is mainly moderately decomposed but fibric and humic layers also occur. Occasionally wood fragments may be found. Where the peat is >40 cm thick, the landform is classified as horizontal fen (C.S.S.C. 1978b). The fen peat is underlain, within the control section, by the fluvial and fluviolacustrine deposits. On some sites Eolian material B containing volcanic ash is preserved in thin layers at or near the base of organic deposits.

Topographically, HC4 displays gentle linear slopes on level floodplains, aprons, and fans. Slopes commonly range from 0 to 9%. Tracts with complex slopes have irregular surfaces reflecting, in part, underlying morainal landforms. Slope continuity is often broken by abandoned and active stream channels including their natural levee borders. Weakly expressed terracing (risers <1 m) is a minor feature on some floodplain tracts.

Soils

Soils of the HC4 Ecosite are complex and reflect recently deposited parent material and varying degrees of gleying, saturation, and organic matter accumulation. These imperfectly, poorly, and very poorly drained soils are best represented by a pattern in which Rego Gleysols are dominant and Gleyed Cumulic Regosols and Terric Mesisols are subdominant. Strength of gleying is variable and reflects degrees of water table fluctuation, lateral water movement, and seepage water aeration. Prolonged periods of saturation produce strongly gleyed soils with little or no pedogenic horizonation (Rego Gleysols). Gleyed Cumulic Regosols and the accessory soils, Gleyed Regosols, Gleyed Eutric Brunisols and Orthic Gleysols, occur where saturation periods are shorter and the depth to the water table is greater. Pedogenic horizonation in the Regosolic soils is limited by active or recently active fluvial deposition. The Gleyed Eutric Brunisols and Orthic Gleysols occur on the oldest surfaces where sufficient time for B horizon development has elapsed. Favorable moisture, nutrient, and vegetation conditions have resulted in the accumulation of varying thicknesses of fen peat on most HC4 soils. Terric Mesisols occur where the peat is >40 cm thick. Other soils with subdominant humic or fibric layers and Humic Gleysols occur occasionally. Well to moder-

ately well drained Brunisolic and Regosolic soils occupy sites where the fluctuating water table is generally below the control section.

A pedon illustrating Rego Gleysols of HC4 is described in Table 205 and shown in Color Plate 27. The top two horizons of this pedon occur in Fluviolacustrine material B. A pedon illustrating Terric Mesisols of HC4 is described in Table 206 and shown in Color Plate 28. The low lime mineral material in this profile (Cg2 and Cg3 horizons) is Fluviolacustrine material A derived from erosion of the quartzite dominated slopes above the floodplain. Because the tract is part of the Sunwapta River floodplain, calcareous Fluviolacustrine material B and Fluvial material B is expected deeper in the profile.

Table 205 Pedon (Alberta 1979 No. 44) description of a Rego Gleysol of the HC4 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: REGO GLEYSOL. SOIL MAP UNIT: NOTATION: HC4.

LOCATION: MILITARY GRID REF. 11 UMJ 3235 3035; NTS MAP AREA 83D 9*.

CLIMATE: 1220 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 10 DEG(C) AT 80 CM IN SEPTEMBER.

VEGETATION: VPN=PA9124*VTN=51*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND SANDY, EXTREMELY CALCAREOUS (>40% CACO3), FLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: FLUVIAL, LEVEL; SLOPE: 0.5% SIMPLE SLOPE OF CLASS 1 (0-0.5%), FACING EAST, SITE AT MIDDLE POSITION, STRONGLY MOUNDED MICROTOPOGRAPHY,1000 M LONG; SOIL MOISTURE AND DRAINAGE: POORLY DRAINED, SLOW SURFACE RUNOFF, SEEPAGE PRESENT; NONSTONY.

SPECIAL NOTES: SSN=GC9065*APN=815027*PCF*6GR(8)*BURRIED FIBRIC AND MESIC ORGANIC MATERIAL IN THE CKB4* ALSO A BURRIED LOG AT 78 CM*DATE*SEPT.6,1979*

CKGJ: 0 TO 14 CM, RANGE 0 TO 16 CM; MATRIX MOIST 2.5Y 5/2; SILT LOAM; COMMON, MEDIUM, DISTINCT, 5Y 6/4 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; VERY FEW, VERY FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

CKG1: 14 TO 25 CM, RANGE 8 TO 12 CM; MATRIX MOIST 2.5Y 5/2; SILT; MANY, FINE, PROMINENT, 7.5YR 5/6 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; VERY FEW, VERY FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

CKG2: 25 TO 42 CM, RANGE 17 TO 20 CM; MATRIX MOIST 2.5Y 5/0; SILT LOAM; MANY, COARSE, PROMINENT, 7.5YR 5/6 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

CKG3: 42 TO 51 CM, RANGE 7 TO 10 CM; MATRIX MOIST 2.5Y 5/0; LOAMY FINE SAND; MANY, COARSE, PROMINENT, 7.5YR 5/6 MOTTLES; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, VERY FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

CKG4: 51 TO 53 CM, RANGE 1 TO 3 CM; MATRIX MOIST 2.5Y 5/0; FINE SANDY LOAM; MANY, COARSE, PROMINENT, 7.5YR 5/6 MOTTLES; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FEW, VERY FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

CKG5: 53 TO 65 CM, RANGE 10 TO 14 CM; MATRIX MOIST 2.5Y 5/0; FINE SANDY LOAM; MANY, COARSE, PROMINENT, 7.5YR 5/6 MOTTLES; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FEW, VERY FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

CKG6: 65 TO 80 CM, RANGE 13 TO 17 CM; MATRIX MOIST 2.5Y 5/0; SAND; MANY, COARSE, PROMINENT, 7.5YR 5/6 MOTTLES; STRUCTURELESS, SINGLE GRAIN STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, VERY FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

CKG7: 80 TO 100 CM; MATRIX MOIST 2.5Y 5/0; SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; FRIABLE CONSISTENCE; 70% GRAVELLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
CKGJ	7.6	2.40	41.1
CKG1	7.5	3.20	51.3
CKG2	7.4	0.10	51.8
CKG3	7.4		44.3
CKG4	7.4		48.4
CKG5	7.4		48.8
CKG6	7.4	0.10	45.5
CKG7	7.7	0.50	53.5

PHYSICAL DATA (SURVEY)

	X PASSING				PARTICLE SIZE ANALYSIS						X OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
CKGJ										1		81	18	
CKG1								1	4	5		87	8	
CKG2						1	1	7	24	33		66	1	
CKG3						1	1	56	17	75		24	1	
CKG4						1	2	46	23	72		25	3	
CKG5						1	4	64	16	85		11	4	
CKG6					1	1	10	66	9	87		11	2	
CKG7					18	29	25	15	2	89		9	2	

Table 206 Pedon (Alberta 1979 No. 36) description of a Terric Mesisol of the HC4 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: TERRIC MESISOL. SOIL MAP UNIT: NOTATION: HC4.

LOCATION: MILITARY GRID REF. 11 UMJ 6750 1260; NTS MAP AREA 83C 6.

CLIMATE: 1490 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 10 DEG(C) AT 50 CM IN AUGUST. NO. 2 WAS 13 DEG(C) AT 10 CM IN AUGUST.

VEGETATION: VPN=LC9162*VTH=S3*.

SOIL SITE: PARENT MATERIAL 1: EXTREMELY TO STRONGLY ACIDIC (PH.5.5), ORGANIC; PARENT MATERIAL 2: CLAYEY (>35% CLAY), MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), FLUVIOLACUSTRINE; LANDFORM CLASSIFICATION: FEN; SLOPE: 1% SLOPE OF CLASS 2 (0.5-2%), FACING NORTH; SOIL MOISTURE AND DRAINAGE: VERY POORLY DRAINED.

SPECIAL NOTES: SSH=GC9056*APH=013-058*LFH=NH/FLL*

OM1: 0 TO 13 CM; NATURAL WET/REDUCED 10YR 2/2, NATURAL WET/OXIDIZED 5YR 3/1; ABUNDANT, VERY FINE ROOTS.

OM2: 13 TO 27 CM; NATURAL WET/REDUCED 5YR 3/2, NATURAL WET/OXIDIZED 5YR 2.5/1; PLENTIFUL, VERY FINE ROOTS.

OM3: 27 TO 45 CM; NATURAL WET/REDUCED 5YR 3/2, NATURAL WET/OXIDIZED 5YR 2.5/2; FEW, VERY FINE ROOTS.

OM3: 45 TO 66 CM; NATURAL WET/REDUCED 10YR 3/2, NATURAL WET/OXIDIZED 5YR 3/2; FEW, VERY FINE ROOTS.

OM4: 66 TO 97 CM; NATURAL WET/REDUCED 10YR 3/3, NATURAL WET/OXIDIZED 5YR 2.5/1.

CG1: 97 TO 103 CM; MATRIX MOIST 5YR 5/1; SILT LOAM; STRUCTURELESS STRUCTURE; NONSTICKY, NONPLASTIC CONSISTENCE; .

CG2: 103 TO 110 CM; MATRIX MOIST 7.5YR 5/6; ASHY LOAM; STRUCTURELESS STRUCTURE; NONSTICKY, NONPLASTIC CONSISTENCE; .

CG3: 110 TO 120 CM; MATRIX MOIST 10YR 5/1; SILTY CLAY; STRUCTURELESS STRUCTURE; NONSTICKY, PLASTIC CONSISTENCE; .

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
OM1	5.0	36.30						
OM2	5.0	37.90						
OM1	5.3	30.70						
OM3	5.6	24.40						
OM4	5.5	42.40						
CG1	6.3	4.10	11.6		17.5	1.2	0.1	0.1
CG2								
CG3	6.0	7.20	31.5		21.6	3.3	0.1	0.2

PHYSICAL DATA (SURVEY)

HORIZON	RUB FIB %	UNRUB FIBRE %	PARTICLE SIZE ANALYSIS X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
OM1	20	60														
OM2	30	60														
OM1	10	40														
OM3	10	30														
OM4	20	40														
CG1												13		79	8	
CG2																
CG3												0		49	51	

Vegetation

Vegetation of the HC4 Ecosite is complex and is best represented by the dwarf birch-shrubby cinquefoil-willow/brown moss (S1), dwarf birch-shrubby cinquefoil/needle-rush (S3), willow/timber oatgrass (S11), and water sedge-beaked sedge (H11) v.t.s. The most abundant v.t. is S1 but some tracts may be dominated by S3 and S11. Occasionally, H11 may be codominant with the shrubby vegetation. The H11 v.t. occurs mostly in ponded localities, often with Organic (Terric Mesisols) soils. Willow-dwarf birch/fleabane (S4), willow/cinquefoil (S8), dwarf birch-willow/kobresia (S9), and sedge-saxifrage (H3) are important accessory v.t.s on HC4. The S4 and S8 v.t.s. are more common at high elevations and may reflect cold air drainage on valley bottom positions. On HC4, S8 and S11 display a wide range of moisture tolerances, occurring on well drained to poorly drained sites. The S11 v.t. is often associated with Gleyed Cumulic Regosols on imperfectly drained sites. The water table probably fluctuates upwards

into the control section only a few times during the growing season on these better drained sites. The H3 v.t. occurs mostly on active stream channel margins where flooding and deposition occur frequently. The willow/horsetail (S7), willow-dwarf birch-shrubby cinquefoil (S10), willow/hairy wild rye (S12), yellow dryad-willow herb (H8), white spruce/shrubby cinquefoil/bearberry (O3), and Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6) v.t.s occur in minor amounts on HC4. Actively aggrading and eroding stream reaches lacking vegetation occupy up to 50% of some tracts. Tracts mapped as HC4+SC have 50 to 80% unvegetated portions. Modification of HC4 vegetation by avalanching, mapped as HC4A, occurs infrequently.

A plot representing vegetation of the Rego Gleysol pedon sample site described above (Table 205) and illustrating S1 on HC4 is presented in Table 207 and Plate 50. A plot representing the vegetation of the Terric Mesisol sample site (Table 206) and illustrating S3 on wetter areas of HC4 is presented in Table 208 and shown in Plate 122.

Table 207 Stand (PA9124) illustrating the dwarf birch-shrubby cinquefoil-willow/brown moss (S1) v.t. of the HC4 Ecosite.

SHRUB LAYER	
Betula glandulosa	20
Potentilla fruticosa	10
Salix lanata	.5
HERB-DWARF SHRUB LAYER	
Antennaria pulcherrima	.5
Arctostaphylos rubra	.5
Arnica mollis	.5
Aster ciliolatus	.5
Aster foliaceus	.5
Calamagrostis inexpansa	.5
Carex flava	10
Carex scirpoidea	10
Deschampsia caespitosa	35
Dryas integrifolia	.5
Juniperus horizontalis	.5
Kobresia myosuroides	.5
Scirpus caespitosus	01
Tofieldia pusilla	01
Zygadenus elegans	.5
BRYOID LAYER	
Campylium stellatum	.5
Ditrichum flexicaule	.5
Hypnum bambergeri	.5
Scorpidium turgescens	10
Tortella fragilis	05

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Table 208 Stand (LC9162) illustrating the dwarf birch-shrubby cinquefoil/needlerush (S3) v.t. of the HC4 Ecosite.

TALL SHRUB LAYER	
Pinus contorta	05
SHRUB LAYER	
Betula glandulosa	10
Pinus contorta	03
Potentilla fruticosa	07
HERB-DWARF SHRUB LAYER	
Allium schoenoprasum	03
Antennaria lanata	.5
Aster spp.	01
Betula glandulosa	03
Carex rostrata	05
Carex vaginata	05
Deschampsia caespitosa	01
Juncus spp.	.5
Kalmia polifolia	01
Ledum groenlandicum	02
Menyanthes trifoliata	02
Oxycoccus microcarpus	.5
Pedicularis groenlandica	.5
Pinguicula vulgaris	01
Potentilla fruticosa	09
Scirpus caespitosus	50
Tofieldia glutinosa	03
Viola spp.	.5
Equisetum fluviatile	03
BRYOID LAYER	
Campylium stellatum	.5
Sphagnum fuscum	05
Tomenthypnum nitens	55

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

The HC4 Ecosite is broad in concept and encompasses wet fluvial terrain dominated by shrubby vegetation in the Lower Subalpine. The Vermilion Lakes 5 (VL5) and Num-Ti-Jah 2 (NT2) Ecosites are the Montane and Upper Subalpine counterparts, respectively, of HC4. Further, the vegetation and soils of NT2 reflect the higher elevations of the Upper Subalpine and slightly drier conditions than on HC4. The wet segments of the Baker Creek 1, 4, and 6 (BK1, BK4, BK6), Cavell 1 (CA1), Consolation Valley 1 (CV1), Topaz (TZ2), and Merlin Castle 1 (MC1) Ecosites sometimes resemble HC4 but are too small to be delineated as HC4 at a mapping scale of 1:50,000. Also, conceptually, these Ecosites have a dry > wet or wet > dry landscape pattern and different landforms with attendant differences in soil and vegetation which distinguishes them from HC4. The HC1 Ecosite is differentiated from HC4 by its closed to open forest dominated vegetation. The HC2 Ecosite is differentiated by its active fluviolacustrine deposition influencing soil and vegetation (Table 200).

HD - HILLSDALE ECOSECTION

The Hillsdale (HD) Ecosection encompasses fluvial landforms (fans, aprons, and floodplains) comprised of calcareous, coarse, stratified fluvial material (Fluvial material B)

throughout the Montane Ecoregion in Banff and Jasper. Channeling (Eroded modifier, C.S.S.C. 1978b) is a common surface feature. Regosolic soils associated with aspen forest, white spruce open and closed forest, white spruce-Douglas fir forest, and grassland > lodgepole pine forest characterize HD.

The HD Ecosection is widely distributed, occurring on lower slopes and valley floors of the Bow and North Saskatchewan River and Lake Minnewanka valleys in Banff. In Jasper, it occurs along the Athabasca, Miette, Whirlpool, Maligne, Snake Indian, Rocky River, and Moosehorn Creek valleys.

Four Ecosites are recognized within the HD Ecosection and are separated primarily on vegetation differences. Table 209 outlines the general features of the HD Ecosection. Representation of HD2 on the landscape is presented in Figure 47 and representation of HD3 is presented in Figure 38. The HD1 and HD4 Ecosites occupy similar landscape positions.

HD1 - HILLSDALE 1 ECOSITE

Ecosite Concept

The Montane Ecosite, HD1, encompasses fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). Surfaces are usually channelled. The soil component is dominated by Orthic and Cumulic Regosols. Vegetation is dominated by the aspen/hairy wild rye-peavine (C16) v.t. The HD1 Ecosite occurs throughout the Montane in Banff and Jasper.

Geomorphology

The HD1 Ecosite is typified by fluvial fans, aprons, and occasionally floodplains consisting of calcareous, coarse, stratified fluvial material (Fluvial material B). Irregular surfaces produced by channeling are common features. Landforms characterizing HD1 consist of materials eroded from the morainal, colluvial and rock slopes occurring above them. Stratified deposits, including interbedded and mixed humus, are manifestations of episodic fluvial deposition. Tracts of HD1 in Jasper north of Jasper Lake in the Athabasca River valley, are overlain by veneers of calcareous, medium textured eolian material (Eolian material A). Some of these deposits may have been reworked by water, making them fluvioeolian deposits. Tracts of HD1 in the Miette River valley and below Pyramid Mountain in Jasper are comprised of noncalcareous, coarse, stratified fluvial material (Fluvial material A). The absence of lime on these tracts is controlled by the surrounding noncalcareous bedrock.

Topographically, HD1 displays linear slopes on fans and aprons. Slopes commonly range from 1 to 15% with the gentler slopes confined to apron and fan toes on valley floors and to minor amounts of level floodplains. Slope continuity is often broken by abandoned and active stream channels including their natural levee margins (Eroded modifier, C.S.S.C. 1978b).

Soils

Soils of the HD1 Ecosite are well drained and reflect relatively recent deposits and periodic depositional activity. Orthic and Cumulic Regosols are dominant. Orthic Eutric Brunisols are accessory soils that occupy slightly elevated portions of the landscape that are rarely flooded. Minor amounts of moderately well drained and gleyed soils occur near the toes of fans and aprons that are seasonally affected by fluctuating water tables. A pedon illustrating Cumulic Regosols of HD1 is described in Table 210 This pedon was sampled on the Carrot Creek fan in Banff.

Vegetation

Vegetation cover on HD1 is dominated by the aspen/hairy wild rye-peavine (C16) v.t. Balsam poplar/buffaloberry (C17) is an accessory v.t. that primarily occurs on portions of HD1 affected by fluctuating water tables. Lodgepole pine and white spruce dominated v.t.s are often mixed with C16 on portions of

Table 209 General features of the Hillsdale (HD) Ecosites.

Ecosite	Landform	Soils	Vegetation
HD1	Fluvial material B; fan, apron	Regosolic	aspen forest
HD2	Fluvial material B; fan, apron, level	Regosolic	white spruce open forest
HD3	Fluvial material B; fan, apron	Regosolic	white spruce forest, white spruce-Douglas fir forest
HD4	Fluvial material B; fan, apron	Regosolic	grassland > lodgepole pine forest

Table 210 Pedon (Alberta 1977 No. 138) description of a Cumulic Regosol of the HDI Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: CUMULIC REGOSOL. SOIL MAP UNIT: NOTATION: HB1.

LOCATION: MILITARY GRID REF. 11 UPG 1030 6730; NTS MAP AREA 82O 3H.

CLIMATE: 1400 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS GOOD RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 10 DEG(C) AT 50.CM IN SEPTEMBER.

VEGETATION: VPN=PA717B=VTN=C16=.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), FLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: FLUVIAL AND UNCONSOLIDATED, FAN; SLOPE: 4% SIMPLE SLOPE OF CLASS 3 (2-5%), FACING SOUTHWEST, SITE AT MIDDLE POSITION, 3080 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, SLOW SURFACE RUNOFF, SEEPAGE ABSENT; NONSTONY.

SPECIAL NOTES: SSN=BW7159=APN=010-224=RLU=15=PCF=3GR(4)10R(9)30R(10)3CB(12)=INCREASE IN CF EXPECTED BELOW 115 CMMANY WHITE MYCELIA INF=THIN DISCONTINUOUS AE AT TOP OF ACK HORIZON=LFH=FF=

F: 5 TO 0 CM, RANGE 3 TO 7 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/2; ABUNDANT, VERY FINE AND COARSE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

ACK: 0 TO 10 CM, RANGE 6 TO 13 CM; HORIZON DRY; MATRIX DRY 10YR 3/2, CRUSHED MOIST 10YR 2/2; SILT LOAM; WEAK, FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND COARSE ROOTS; FEW, FINE PORES; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; MANY, FINE, RANDOM, STREAKED SECONDARY CARBONATES WITH VERY FRIABLE CONSISTENCE, 10YR 8/1; WAVY, CLEAR HORIZON BOUNDARY.

CK1: 10 TO 30 CM, RANGE 12 TO 23 CM; HORIZON DRY; MATRIX DRY 10YR 5/2, CRUSHED MOIST 10YR 4/2; SILT; MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO AND FINE ROOTS; FEW, VERY FINE PORES; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CK2: 30 TO 36 CM, RANGE 3 TO 10 CM; HORIZON DRY; MATRIX DRY 10YR 4/2, MATRIX MOIST 10YR 3/2; FINE SANDY LOAM; SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; ABUNDANT, VERY FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK3: 36 TO 49 CM, RANGE 14 TO 20 CM; HORIZON DRY; MATRIX DRY 10YR 5/2, MATRIX MOIST 10YR 4/2; SILT LOAM; MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE ROOTS; FEW, FINE PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

BMBK1: 49 TO 54 CM, RANGE 4 TO 7 CM; HORIZON DRY; MATRIX DRY 5YR 5/4, MATRIX DRY 10YR 4/3; SILT LOAM; MASSIVE STRUCTURE; MODERATE, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE; FRIABLE CONSISTENCE; ABUNDANT, MICRO ROOTS; COMMON, FINE PORES; MODERATE EFFERVESCENCE; MODERATELY CALCAREOUS; MANY, FINE, RANDOM, STREAKED SECONDARY CARBONATES WITH FRIABLE CONSISTENCE, 10YR 8/1; WAVY, CLEAR HORIZON BOUNDARY.

CKB1: 54 TO 68 CM, RANGE 11 TO 15 CM; HORIZON DRY; MATRIX DRY 10YR 4/2.5, MATRIX MOIST 10YR 3/2.5; SILT LOAM; MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; COMMON, FINE PORES; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CKB2: 68 TO 78 CM, RANGE 8 TO 10 CM; HORIZON DRY; MATRIX DRY 10YR 4/2, CRUSHED MOIST 10YR 3/2; FINE SANDY LOAM; MASSIVE STRUCTURE; SINGLE GRAIN SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; FEW, FINE PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CKB3: 78 TO 84 CM, RANGE 3 TO 6 CM; HORIZON DRY; MATRIX DRY 10YR 4/3, MATRIX MOIST 10YR 3/3; SILT LOAM; MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; MANY, FINE PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CKB4: 84 TO 88 CM, RANGE 3 TO 5 CM; HORIZON DRY; MATRIX DRY 10YR 4/2, MATRIX MOIST 10YR 3/2; SANDY LOAM; MASSIVE STRUCTURE; WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; FEW, FINE PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CKB5: 88 TO 100 CM, RANGE 11 TO 14 CM; HORIZON DRY; MATRIX DRY 10YR 5/3, MATRIX MOIST 10YR 4/3; SILT LOAM; MASSIVE STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, VERY FINE ROOTS; MANY, VERY FINE PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

BMBK2: 100 TO 115 CM; HORIZON DRY; MATRIX DRY 7.5YR 5/4, CRUSHED MOIST 5YR 3/4; SILT LOAM; MASSIVE STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, VERY FINE ROOTS; MANY, FINE PORES; STRONG EFFERVESCENCE; MODERATELY CALCAREOUS; COBBLY COARSE FRAGMENTS.

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	X PASSING .75" SIEVE	X PASSING NO.4 SIEVE	X PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 79- 2U SILT	99- 2U SILT	2U CLAY	0.2U CLAY
F														
ACK					0	0	0	1	0	4		79	18	3
CK1					0	0	0	1	10	11		82	7	5
CK2					3	3	10	30	10	64		31	5	2
CK3					0	0	1	12	20	33		59	8	2
BMBK1										4		76	20	6
CKB1										9		77	14	2
CKB2					0	3	24	33	16	76		20	4	1
CKB3					3	6	6	7	7	29		57	14	3
CKB4		99	99	74	61	12	12	7	17	7	76	16	8	2
CKB5					0	1	1	3	9	14		72	14	4
BMBK2					0	1	2	9	11	23		57	20	2

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CAPB EQU.%
F	6.1	32.90	
ACK	7.9	4.02	29.8
CK1	7.1	1.10	35.4
CK2	7.2	1.30	48.6
CK3	7.3	1.00	42.6
BMBK1	7.3	1.70	4.0
CKB1	7.5	1.60	29.4
CKB2	7.5	0.00	50.8
CKB3	7.6	1.40	49.9
CKB4	7.7	1.00	58.2
CKB5	7.5	2.10	41.2
BMBK2	7.6	1.90	8.9

PHYSICAL DATA

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
F								
ACK								
CK1								
CK2								
CK3								
BMBK1								
CKB1								
CKB2								
CKB3								
CKB4	0.0	0.0						
CKB5	25.0	31.0					12	97
BMBK2								

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
F				
ACK				
CK1				
CK2				
CK3				
BMBK1	0.1		-.1	
CKB1				
CKB2				
CKB3				
CKB4				
CKB5				
BMBK2	0.1		-.1	

tracts but due to the mapping scale used, are impossible to separate. An example of this mix is the fan at the base of Mount Kerkeslin in Jasper. A stand illustrating the C16 v.t. is described in Table 211 and shown in Plate 123 and represents the vegetation at the pedon sample site described in Table 210.

Table 211 Stand (PA7175) illustrating the aspen/hairy wild rye-peavine (C16) v.t. of the HD1 Ecosite.

TREE LAYER	
Populus balsamifera	05
Populus tremuloides	55
TALL SHRUB LAYER	
Populus balsamifera	01
SHRUB LAYER	
Picea glauca	.5
Populus tremuloides	.5
Shepherdia canadensis	05
HERB-DWARF SHRUB LAYER	
Achillea millefolium	.5
Arctostaphylos uva-ursi	.5
Aster conspicuus	02
Bromus inermis	.5
Calamagrostis rubescens	60
Elymus innovatus	01
Epilobium angustifolium	03
Fragaria virginiana	05
Galium boreale	02
Hedysarum sulphurescens	05
Lathyrus ochroleucus	01
Oxytropis spp.	.5
Pyrola secunda	02
Rosa acicularis	.5
Senecio indecorus	.5
Smilacina stellata	02
Symphoricarpos occidentalis	10
Vicia americana	.5
Viola rugulosa	.5
Zygadenus elegans	.5
BRYOID LAYER	
Hylocomium splendens	.5
EPIPHYTES	
Pylaisiella polyantha	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

Portions of fluvial landscapes in the Montane Ecoregion with the aspen/hairy wild rye-peavine (C16) v.t. may resemble but not be mapped as HD1. This happens because their areal extent is too small to be delineated at a 1:50,000 map scale. They thus occur in minor amounts in other Ecosites. The Pipestone 2 (PP2) Ecosite is the Lower Subalpine counterpart of HD1. The HD1 Ecosite is separated from other HD Ecosites primarily on vegetation differences as outlined in Table 209.

HD2 - HILLSDALE 2 ECOSITE

Ecosite Concept

The Montane Ecosite, HD2, encompasses fluvial fans, aprons, and floodplains comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). Surfaces are usually channeled. The soil component is dominated by Orthic and Cumulic Regosols. Vegetation is dominated by the white spruce/shrubby cinquefoil/bearberry (O3) v.t.

In Jasper, the majority of HD2 tracts occur along the Athabasca River valley north of the Snaring River to Jasper's East Gate. In Banff, HD2 tracts occur throughout the Montane in the Bow and North Saskatchewan River valleys.

Geomorphology

The HD2 Ecosite is typified by fluvial fans, aprons, and level floodplains consisting of calcareous, coarse, stratified fluvial material (Fluvial material B). Irregular surfaces produced by channelling are common features. Stratified deposits, including interbedded and mixed humus, are manifestations of episodic fluvial deposition. In Jasper, HD2 tracts north of Jasper Lake in the Athabasca River valley are overlain by veneers of calcareous, medium textured eolian material (Eolian material A). Some of these deposits have been reworked by water, making them fluvioeolian deposits.

Topographically, HD2 is characterized by linear slopes on fans and aprons. Slopes commonly range from 1 to 15% with the gentler slopes confined to fan and apron toes, and level floodplains on valley floors. Slope continuity is often broken by abandoned and active stream channels including their natural levee margins.

Soils

Soils of the HD2 Ecosite are well to moderately well drained and reflect relatively young deposits and periodic depositional activity. Orthic and Cumulic Regosols are dominant. Minor amounts of Gleyed Cumulic Regosols occur on imperfectly drained sites that are seasonally affected by fluctuating water tables. These soils are commonly found on the wetter portions of eroded (channeled) floodplains and the toes of fluvial fans and aprons. A pedon illustrating Cumulic Regosols of HD2 is described in Table 212. This pedon was sampled on the Rocky River fan in Jasper. The upper 74 cm of this pedon is possibly a veneer of calcareous, medium textured eolian material (Eolian material A).

Table 212 Pedon (Alberta 1978 No. 18) description of a Cumulic Regosol of the HD 2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: CUMULIC REGOSOL. SOIL MAP UNIT: NOTATION: HD2.

LOCATION: MILITARY GRID REF. 11 UNJ 3800 3765; NTS MAP AREA 83F 4W.

CLIMATE: 1000 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS MODERATE RELEVANCE TO THE SOIL SITE.

VEGETATION: VPN=SJ8003=VTH=003=..

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), FLUVIAL, UNDIFFERENTIATED OR UNDETERMINED; LANDFORM CLASSIFICATION: FLUVIAL, FAN; SLOPE: 2% SIMPLE SLOPE OF CLASS 2 (0.5-2%), FACING NORTHWEST, SITE AT MIDDLE POSITION, LEVEL MICROTOPOGRAPHY;1000 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, SEEPAGE ABSENT; NONSTONY; NONROCKY; PRESENT LAND USE: OUTDOOR RECREATION.

SPECIAL NOTES: SSN=RN8004=APN=018=PCF=6GR,2CB(8)=LFH=FF=

AHK: 0 TO 6 CM, RANGE 4 TO 6 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/2; SILT LOAM; WEAK, VERY FINE, GRANULAR STRUCTURE; VERY FRIABLE, NONPLASTIC CONSISTENCE; FEW AND ABUNDANT, FINE AND MEDIUM, RANDOM ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, DENDRITIC, TUBULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, CLEAR HORIZON BOUNDARY.

CK1: 6 TO 11 CM, RANGE 5 TO 8 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/2; SILT; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, FINE AND MEDIUM, RANDOM ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, DENDRITIC, TUBULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, CLEAR HORIZON BOUNDARY.

AHKB1: 11 TO 21 CM, RANGE 10 TO 14 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 3/2; SILT; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, FINE AND MEDIUM, RANDOM ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, DENDRITIC, TUBULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, CLEAR HORIZON BOUNDARY.

CK2: 21 TO 44 CM, RANGE 14 TO 23 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/3; SILT; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM, RANDOM ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, DENDRITIC, TUBULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, CLEAR HORIZON BOUNDARY.

AHKB2: 44 TO 54 CM, RANGE 7 TO 12 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 3/2; SILT; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM, RANDOM ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, DENDRITIC, TUBULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; COMMON, FINE, RANDOM, ROUNDED SECONDARY CARBONATES WITH VERY FRIABLE CONSISTENCE; WAVY, ABRUPT HORIZON BOUNDARY.

CK3: 54 TO 74 CM, RANGE 15 TO 23 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/3; SILT; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE AND MEDIUM, RANDOM ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, DENDRITIC, TUBULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, CLEAR HORIZON BOUNDARY.

AHKB3: 74 TO 90 CM, RANGE 12 TO 15 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/2; VERY FINE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE AND MEDIUM, RANDOM ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, DENDRITIC, TUBULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; MANY, FINE, RANDOM, ROUNDED SECONDARY CARBONATES WITH VERY FRIABLE CONSISTENCE; SMOOTH, CLEAR HORIZON BOUNDARY.

CK4: 90 TO 110 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/2; VERY GRAVELLY FINE SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; VERY FEW, FINE, RANDOM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 10% AND 60% GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CACO3 EQU.%
AHK	7.2	5.40	47.6
CK1	7.3	2.00	53.0
AHKB1	7.3	5.50	52.3
CK2	7.5	0.70	60.8
AHKB2	7.4	1.13	58.4
CK3	7.5	0.90	59.9
AHKB3	7.7	1.10	49.3
CK4	7.6	1.40	59.1

PHYSICAL DATA (SURVEY)

	% PASSING				PARTICLE SIZE ANALYSIS						% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
AHK														
CK1	99	99	99	99			2	1	11	14		76	10	
AHKB1							1	1	10	12		83	5	
CK2										5		89	6	
AHKB2										9		86	5	
CK3										7		87	6	
AHKB3										5		88	7	
CK4	99	46	25	23	7	9	4 19	27 22	20 8	51 65		42 30	7 5	

PHYSICAL DATA

	MOISTURE STATUS (%)					ATTERBURG	ATTERBURG	SHRINKAGE	ENGINEERING OPT MOIST	MAX DRY			
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	LIMIT (%)	CONTENT (%)	DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AHK													
CK1		14.0	7.0										
AHKB1												48	10
CK2													
AHKB2													
CK3		22.0	8.6										
AHKB3													
CK4		9.9	3.3										
												11	02

Vegetation

The vegetation component of HD2 is dominated by the white spruce/shrubby cinquefoil/bearberry (O3) v.t. The white spruce/juniper/bearberry (O17) and yellow dryad-willow herb (H8) v.t.s occur in minor amounts. The H8 v.t. is usually found on and adjacent to active stream channels. A stand illustrating the O3 v.t. on HD2 is described in Table 213 and shown in Plate 37 and represents the vegetation at the pedon sample site described above in Table 212.

Table 213 Stand (SJ8003) illustrating the white spruce/shrubby cinquefoil/bearberry (O3) v.t. of the HD2 Ecosite.

TREE LAYER	
Picea glauca	10
TALL SHRUB LAYER	
Picea glauca	06
SHRUB LAYER	
Juniperus communis	02
Juniperus horizontalis	12
Picea glauca	04
Potentilla fruticosa	16
HERB-DWARF SHRUB LAYER	
Androsace chamaejasme	04
Antennaria nitida	06
Arctostaphylos uva-ursi	38
Calamagrostis purpurascens	12
Carex eburnea	06
Carex filifolia	.5
Carex richardsonii	06
Carex scirpoidea	22
Draba spp.	02
Galium boreale	.5
Hedysarum alpinum	10
Koeleria cristata	.5
Lilium philadelphicum	02
Oryzopsis asperifolia	01
Oxytropis splendens	02
Solidago decumbens	04
Zygadenus elegans	14
BRYOID LAYER	
Bryoerythrophyllum recurvirostrum	.5
Bryum pseudotriquetrum	.5
Bryum spp.	.5
Distichium capillaceum	.5
Ditrichum flexicaule	.5
Encalypta vulgaris	.5
Hypnum cupressiforme	.5
Peltigera canina	.5
Squamarina lentigera	.5
Stegonia latifolia	.5
Thuidium abietinum	.5
Toninia coeruleonigricans	.5
Tortella tortuosa	.5
Tortula ruralis	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The HD2 Ecosite may resemble portions of the Vermilion Lakes 3 (VL3) Ecosite where the O3 v.t. occurs. However, VL3 is generally on poorly drained floodplains, whereas HD2 occurs on moderately well drained fans. The Pipestone 6 (PP6) Ecosite is the Lower Subalpine counterpart of HD2. The HD2 Ecosite is separated from other HD Ecosites primarily on vegetation differences as outlined in Table 209.

HD3 - HILLSDALE 3 ECOSITE

Ecosite Concept

The Montane Ecosite, HD3, encompasses fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). Surfaces are usually channeled. The soil component is dominated by Orthic and Cumulic Regosols. Vegetation is dominated by the white spruce/fern moss (C2), white spruce/prickly rose/fern moss (C27), white spruce-Douglas fir/feathermoss (C5) and white spruce/buffaloberry/fern moss (C26) v.t.s. The most abundant v.t.s are C2 and C27. The HD3 Ecosite is found throughout the Montane in both parks.

Geomorphology

The HD3 Ecosite occurs on fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). Irregular surfaces produced by channeling are common features. Stratified deposits, including interbedded and admixed humus, are manifestations of episodic fluvial deposition. In Jasper, HD3 tracts in the Athabasca River valley north of Jasper Lake are overlain by calcareous, medium textured eolian material (Eolian material A). Some of these deposits have been reworked by water, making them fluvioeolian deposits. Tracts mapped as HD3 in the Miette River valley in Jasper are comprised of noncalcareous, coarse, stratified fluvial material (Fluvial material A).

Topographically, HD3 displays linear slopes on fans and aprons. Slopes commonly range from 1 to 15% with gentler slopes confined to apron and fan toes on valley floors and to a minor proportion of level floodplains and fluvial terraces. Slope continuity is often broken by abandoned and active stream channels including their natural levee margins.

Soils

Soils of the HD3 Ecosite are well to moderately well drained and reflect relatively young deposits and periodic depositional activity. Orthic and Cumulic Regosols are dominant. Orthic Eutric Brunisols are accessory soils that occupy slightly elevated portions of the landscape that are rarely flooded. Minor amounts of gleyed soils occur near the toes of fans and aprons that are seasonally affected by fluctuating water tables. A pedon

Table 214 Pedon (Alberta 197[illegible] No. 99) description of a Cumulic Regosol of the HD3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: CUMULIC REGOSOL. SOIL MAP UNIT: NOTATION: HD3.

LOCATION: MILITARY GRID REF. 11 UPG 470 6928; NTS MAP AREA 82O 4E.

CLIMATE: 1400 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS GOOD RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VPN=PA8168WVTN=CBB=.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, SKELETAL (>35% OF PARTICLES 8-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND STRATIFIED (MINERAL), EXTREMELY CALCAREOUS (>40% CACO3), FLUVIAL; LANDFORM CLASSIFICATION: FLUVIAL, APRON; SLOPE: 24% SIMPLE SLOPE OF CLASS 6 (16-30%), FACING NORTH, SITE AT LOWER SLOPE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,200 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; NONSTONY; NONROCKY.

SPECIAL NOTES: SSN=BW8146=APN=010-223=RLU=15=PCF=16R(6)6GR.2CB.1ST(7-8)=

LF: 6 TO 0 CM, RANGE 4 TO 0 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/2; SILT LOAM; VERY FEW, VERY FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

B+AK: 0 TO 4 CM, RANGE 3 TO 6 CM; HORIZON DRY; MATRIX DRY 10YR 4/3, MATRIX DRY 10YR 7/3; SILT LOAM; VERY WEAK, VERY FINE, GRANULAR STRUCTURE; SOFT CONSISTENCE; ABUNDANT, FINE AND COARSE ROOTS; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CK1: 4 TO 20 CM, RANGE 11 TO 18 CM; HORIZON DRY; MATRIX DRY 2.5Y 4/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SLIGHTLY HARD CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND MEDIUM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

BMBK1: 20 TO 26 CM, RANGE 4 TO 8 CM; HORIZON DRY; MATRIX DRY 10YR 5/3; SILT LOAM; VERY WEAK, VERY FINE, GRANULAR STRUCTURE; SOFT CONSISTENCE; PLENTIFUL, VERY FINE AND FINE AND MEDIUM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CK2: 26 TO 34 CM, RANGE 6 TO 12 CM; HORIZON DRY; MATRIX DRY 2.5Y 4/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SLIGHTLY HARD CONSISTENCE; FEW, VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

BMBK2: 34 TO 38 CM, RANGE 3 TO 11 CM; HORIZON DRY; MATRIX DRY 5YR 3/2, MATRIX DRY 7.5YR 4/4; SILT LOAM; VERY WEAK, MEDIUM, GRANULAR STRUCTURE; SOFT CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

AMKB: 38 TO 57 CM, RANGE 13 TO 39 CM; HORIZON DRY; MATRIX DRY 10YR 3/2; SILT LOAM; VERY WEAK, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; SOFT CONSISTENCE; ABUNDANT, MICRO AND VERY FINE ROOTS; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; 70% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

CK3: 57 TO 105 CM; HORIZON DRY; MATRIX DRY 5Y 3/2; SILT LOAM; VERY WEAK, FINE, GRANULAR STRUCTURE; SLIGHTLY HARD CONSISTENCE; PLENTIFUL, MICRO ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 70% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LF	7.0	26.80	11.8
B+AK	8.0	3.40	38.1
CK1	7.7		35.7
BMBK1	8.0	5.30	40.6
CK2	8.0		60.4
BMBK2	7.9	3.40	49.5
AMKB	7.9	6.30	25.9
CK3	8.0		65.6

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
B+AK				
CK1				
BMBK1	0.1		-.1	
CK2				
BMBK2	0.1		-.1	
AMKB				
CK3				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
B+AK														
CK1										25		65	10	
BMBK1										18		69	13	
CK2										18		69	13	
BMBK2										34		55	11	
AMKB										26		60	14	
CK3	99	54	27	23						23		58	19	
										38		51	11	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
B+AK		31.4	17.4										
CK1													
BMBK1													
CK2		86.6	8.6										
BMBK2													
AMKB													
CK3		17.1	4.8			16.0	21.0		12.0	1.9		11	17

illustrating Cumulic Regosols of the HD3 Ecosite is described in Table 214 and shown in Color Plate 29. This pedon was sampled above the Bow River southeast of the golf course in Banff.

Vegetation

The HD3 Ecosite is dominated by the white spruce/fern moss (C2), white spruce/prickly rose/fern moss (C27), with lesser amounts of white spruce-Douglas fir/feathermoss (C5), and white spruce/buffaloberry/fern moss (C26) v.t.s. A few HD3 tracts are dominated by C5 or C26. The C2, C26 and C27 v.t.s are generally associated with veneers of calcareous, medium textured eolian material (Eolian material A) along the North Saskatchewan River valley in Banff and the Athabasca River valley north of Jasper townsite. Also, C26 occurs on the Snake Indian River floodplain below the Seldom Inn warden cabin in Jasper. The calciphile, *Thuidium abietinum*, is the predominant moss in the understory of the above v.t.s and usually occurs on calcareous materials. In Banff, C5 is more abundant than in Jasper, commonly occurring on northerly aspects. A stand illustrating the C5 v.t. on HD3 is described in Table 215 and shown in Plate 124 and represents vegetation at the pedon sample site described above in Table 214.

Table 215 Stand (PA8165) illustrating the white spruce-Douglas fir/feathermoss (C5) v.t. of the HD3 Ecosite.

TREE LAYER	
Picea glauca	35
Pseudotsuga menziesii	25
TALL SHRUB LAYER	
Picea glauca	.5
Pseudotsuga menziesii	.5
SHRUB LAYER	
Picea glauca	.5
HERB-DWARF SHRUB LAYER	
Aster conspicuus	.5
Carex concinnoides	.5
Elymus innovatus	.5
Juniperus communis	15
Linnaea borealis	10
Pyrola secunda	.5
Rosa acicularis	03
Shepherdia canadensis	.5
BRYOID LAYER	
Cetraria nivalis	.5
Ditrichum flexicaule	.5
Hylocomium splendens	60
Hypnum revolutum	15
Lecanora epibyron	.5
Orthotrichum obtusifolium	.5
Orthotrichum pallens	.5
Orthotrichum speciosum	.5
Pannaria microphylla	.5
Peltigera aphthosa	10
Peltigera canina	.5
Pylaisiella polyantha	.5
Thuidium abietinum	05
Tortella tortuosa	10
EPIPHYTES	
Hypogymnia physodes	.5
Lecanora hagenii	.5
Letharia vulpina	.5
Ramalina fastigiata	.5
Usnea alpina	.5
Usnea cavernosa	.5
Usnea sorediifera	.5
Usnea subfloridana	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

The Pipestone 3 (PP3) Ecosite is the Lower Subalpine counterpart of HD3. The HD3 Ecosite is separated from the other HD Ecosites primarily on vegetation differences as outlined in Table 209.

HD4 - HILLSDALE 4 ECOSITE

Ecosite Concept

The Montane Ecosite, HD4, encompasses fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). Surfaces are usually channeled. Orthic and Cumulic Regosols are the dominant soils associated with a pattern of vegetation dominated by the junegrass-pasture sage-wild blue flax (H6) v.t. and a lesser percentage of the lodgepole pine/juniper/bearberry (C3) v.t.

In Jasper, HD4 tracts primarily occur in the Athabasca River valley between Jasper townsite and Jasper's East Gate. In Banff two tracts of HD4 occur, one at Hillsdale and the other in the vicinity of the Banff airport.

Geomorphology

The HD4 Ecosite encompasses fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). Irregular surfaces produced by channeling are common features. Stratified deposits, including interbedded and mixed humus, are manifestations of episodic fluvial deposition. In Jasper, HD4 tracts north of Jasper Lake in the Athabasca River valley are overlain by veneers of calcareous, medium textured eolian material (Eolian material A). Some of these deposits have been reworked by water, making them fluvioeolian deposits.

Topographically, HD4 displays linear slopes on fans and aprons. Slopes commonly range from 1 to 15% with gentler slopes confined to fan and apron toes on valley floors. Slope continuity is often broken by abandoned and active stream channels including their natural levee margins.

Soils

Soils of the HD4 Ecosite are rapidly to well drained and reflect relatively recent deposits and periodic depositional activity. Orthic and Cumulic Regosols are dominant. Orthic Eutric Brunisols occur in minor amounts on slightly elevated portions of the landscape that are rarely flooded. Organically enriched (Ah) horizons develop under grassland on HD4 tracts affected by veneers of calcareous, medium textured eolian material (Eolian material A), resulting in minor amounts of Orthic and Cumulic Humic Regosols. A pedon illustrating Cumulic Regosols of HD4 is described in Table 216 and shown in Color Plate 30. This pedon was sampled between Edith Lake and the confluence of the Maligne and Athabasca Rivers in Jasper. This pedon has horizons with organic matter contents that vary irregularly with depth, making it a Cumulic Regosol.

Vegetation

The vegetation pattern of HD4 is dominated by the junegrass-pasture sage-wild blue flax (H6) v.t., with a lesser abundance of the lodgepole pine/juniper/bearberry (C3) v.t. Historically, fire has had a major effect on HD4 tracts. In Jasper, the addition of calcareous, medium textured eolian material (Eolian material A) is also a factor contributing to the vegetation assemblage. Minor amounts of the white spruce/juniper/bearberry (O17) and white spruce/shrubby cinquefoil/ bearberry (O3) v.t.s occupy localities where eolian material is still actively aggrading. A plot illustrating the H6 v.t. of HD4 is described in Table 217 and shown in Plate 125 and represents the vegetation at the pedon sample site described above in Table 216.

Table 216 Pedon (Alberta 1975 No. 115) description of a Cumulic Regosol of the HD4 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1970. SUBGROUP: CUMULIC REGOSOL. SOIL MAP UNIT: NOTATION: HD4.

LOCATION: LAT: 52 DEG 55 MIN 30 SEC, LONG: 118 DEG 1 MIN 30 SEC; MILITARY GRID REF. 11 UND 3080 6420; NTS MAP AREA 83D 16H.

CLIMATE: 1030 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS GOOD RELEVANCE TO THE SOIL SITE.

VEGETATION: VPN=ICS018*VTN=H6*.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING. SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), FLUVIAL, MIXED AND SILTSTONE AND MUDSTONE AND QUARTZITE; LANDFORM CLASSIFICATION: UNCONSOLIDATED AND FLUVIAL, FAN; SLOPE: 1% SIMPLE SLOPE OF CLASS 2 (0.5-2%), FACING WEST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,1000 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, SLOW SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY; PRESENT LAND USE: OUTDOOR RECREATION.

SPECIAL NOTES: SSM=PWS010*APN=015-110*RLU=15,13*WLU=F2,F3*PCF=1GR(1-2)3CB,SADR(3-4)4GR,4CB(5)*ROOT MATS ON COBBLES(4)*FEW FLAGGY FRAG SILTSTONE(3-5)*SSC=CB*ST*LFM=FF*

AHK: 0 TO 3 CM, RANGE 2 TO 4 CM; MATRIX DRY 10YR 5/2, MATRIX MOIST 10YR 4/2; SILT LOAM; LOOSE, LOOSE CONSISTENCE; ABUNDANT, FINE ROOTS; STRONG EFFERVESCENCE; CLEAR HORIZON BOUNDARY.

CK1: 3 TO 12 CM, RANGE 8 TO 12 CM; MATRIX DRY 10YR 7/3, MATRIX MOIST 10YR 6/3; SILT LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE, LOOSE CONSISTENCE; ABUNDANT, FINE ROOTS; STRONG EFFERVESCENCE; MODERATELY CALCAREOUS; GRAVELLY COARSE FRAGMENTS; CLEAR HORIZON BOUNDARY.

CK2: 12 TO 23 CM, RANGE 8 TO 15 CM; MATRIX DRY 7.5YR 5/2, MATRIX MOIST 7.5YR 4/2; GRAVELLY SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE, LOOSE CONSISTENCE; ABUNDANT, FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; GRAVELLY AND ANGULAR GRAVELLY COARSE FRAGMENTS; CLEAR HORIZON BOUNDARY.

CK3: 23 TO 70 CM, RANGE 45 TO 50 CM; MATRIX DRY 10YR 5/1, MATRIX MOIST 10YR 5/2; GRAVELLY LOAMY COARSE SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE, LOOSE CONSISTENCE; WEAKLY CEMENTEDBY LIME; PLENTIFUL, FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; GRAVELLY AND ANGULAR GRAVELLY COARSE FRAGMENTS; GRADUAL HORIZON BOUNDARY.

CK4: 70 TO 110 CM; MATRIX DRY 10YR 6/1, MATRIX MOIST 10YR 4.5/2; GRAVELLY SILT LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE, LOOSE CONSISTENCE; FEW, FINE ROOTS, MODERATE EFFERVESCENCE; EXTREMELY CALCAREOUS; GRAVELLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	TOTAL N (%)	CALC CARB EQU.%
AHK	7.3	5.20	0.40	
CK1	7.1	2.10		8.6
CK2	7.2	0.80		74.8
CK3	7.5	2.40		65.9
CK4	7.4	0.90		58.7

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
AHK														
CK1										38		52	10	2
CK2										38		53	9	1
CK3					9	13	25	19	6	70		22	8	4
CK4					30	29	13	5	2	79		16	5	2
					13	11	5	2	1	32		64	4	1

Table 217 Stand (IC5010) illustrating the june grass-pasture sage-wild blue flax (H6) v.t. of the HD4 Ecosite.

SHRUB LAYER	
Symphoricarpos albus	.5
HERB-DWARF SHRUB LAYER	
Achillea millefolium	.5
Agropyron dasystachyum	01
Amelanchier alnifolia	.5
Androsace chamaejasme	.5
Anemone multifida	.5
Antennaria nitida	07
Arenaria rubella	.5
Aster alpinus	.5
Campanula rotundifolia	.5
Carex eleocharis	.5
Erigeron compositus	02
Erigeron glabellus	.5
Erysimum cheiranthoides	.5
Gaillardia aristata	.5
Galium boreale	.5
Koeleria cristata	10
Linum lewisii	.3
Poa cusickii	.5
Potentilla norvegica	.5
Rosa acicularis	.5
Shepherdia canadensis	.5
Senecio cymbalarioides	01
Solidago decumbens	.5
Taraxacum officinale	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The HD4 Ecosite is the least extensive of the HD Ecosites. Presently, there exists a tension between grassland and forest on HD4 tracts. Forest encroachment of the grassland is slowly reducing its acreage. Evidence of this hypothesis is given in the discussion section of the Athabasca 3 (AT3) Ecosite. In terms of landform surface expression, soils, and vegetation cover, HD4 most resembles the AT3 Ecosite. They also have similar eolian veneers but AT3 occurs on terraces of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) whereas HD4 occurs on fluvial fans. The HD4 Ecosite is separated from other HD Ecosites primarily on vegetation differences as outlined in Table 209.

HE - HEATHER ECOSECTION

The HE Ecosection occurs on either rock (consolidated) or residuum (unconsolidated bedrock) in the Alpine Ecoregion. Lithic phases of Brunisolic and Regosolic soils dominate areas where soil exists, but areas of nonsoil (surface veneers <10 cm thick over bedrock) are common. Mountain avens tundra vegetation mantles most areas except the unvegetated bedrock outcrops, where vegetation is extremely sparse.

The HE Ecosection occurs at high elevations throughout Banff and Jasper, with distribution and extent controlled by bedrock structure, lithology, and surface topography. Examples are mapped north of Mount Eisenhower in Banff and on the De Smet Range in Jasper. Two Ecosites (HE1, HE2) are recognized, with separation based on the occurrence and nature of consolidated versus unconsolidated bedrock and the resultant effects on soil and vegetation as outlined in Table 218.

HE1 - HEATHER 1 ECOSITE

Ecosite Concept

The HE1 Ecosite occurs on both noncalcareous, medium textured residuum (Residuum A) and calcareous, medium textured residuum (Residuum B) veneers over inclined, hummocky, and ridged bedrock in the Alpine ecoregion. Soils are lithic and often include turbic phases of Orthic Sombric Brunisols, Orthic Melanic Brunisols, and Orthic Humic Regosols. Vegetation is dominantly the mountain avens-snow willow-moss campion (H1) v.t.

The HE1 Ecosite occupies high plateaus, broad passes and rounded mountain peaks and ridges underlain by recessive, highly jointed, medium and fine grained clastic rocks, both calcareous and noncalcareous.

The HE1 Ecosite is distributed sporadically throughout both Banff and Jasper. An extensive example mantling the De Smet Range in Jasper is shown in Plate 126.

Table 218 General features of the heather (HE) Ecosites.

Ecosite	Landform	Soils	Vegetation
HE1	Residuum A,B; inclined, hummocky, ridged	lithic phases of Brunisols and Regosols	mountain avens tundra
HE2	Calcareous bedrock; ridged > calcareous regolith veneer over rock	Nonsoil >> lithic phases of Brunisols and Regosols	Unvegetated > mountain avens tundra

Geomorphology

The HE1 Ecosite occurs on both noncalcareous, medium textured residuum (Residuum A) and calcareous, medium textured residuum (Residuum B) in the Alpine Ecoregion. These genetic materials occupy complex slopes of up to 45%, and occur as veneers over the inclined, hummocky, or ridged bedrock from which they were derived. Steeper slopes on HE1 are frequently soliflucted, producing a variant of colluvial material that resembles the original residuum. On exposed positions, some gentler slopes show evidence of either active or inactive cryoturbation.

This Ecosite occurs in two different topographic situations that have different genetic material histories. Occasionally, tracts occupy high, broad plateaus and passes. These areas generally have been glaciated, and till occurs locally or is mixed with the residuum. More frequently HE1 is mapped on higher, rounded mountain peaks and ridges that show little evidence of, or may have escaped, glaciation (Stalker 1973, Harrison 1976). These surfaces may be much older than the lower, glaciated ones.

In both instances, residuum (soil parent material) was produced by both physical and weak chemical weathering of highly jointed, medium and fine grained recessive rock. Frost activity along jointing (joint-block separation) resulted in a much greater surface area exposed to weathering of the cement holding the grains of the rock together. These processes are still active on HE1. Failed bedrock accounts for only a few tracts of HE1.

A strong relationship exists between the nature of the underlying bedrock and the physical and chemical characteristics of the resulting residuum. In the Main Ranges, HE1 occurs nearly exclusively on Residuum A derived from Miette Group strata. Mesozoic strata in the Front Ranges generally produce either Residuum B on the Triassic aged Spray River Group, or Residuum A on Jurassic and Lower Cretaceous bedrock. Tracts of greatest extent and uniformity occur where bedding planes of in situ, residuum-producing bedrock conform closely to the ground surface (Plate 126). Irregular surfaces cutting across differing strata produce small tracts with locally diverse characteristics, often including both Residuum A and Residuum B.

Intact eolian veneers are not common on HE1 but the material may often have been incorporated into the residuum by cryoturbation or solifluction. On exposed sites these processes occasionally produce bare mineral soil that is subject to deflation.

Soils

Soils occurring on HE1 are taxonomically diverse with lithic phases of Orthic Sombric Brunisols, Orthic Melanic Brunisols, and Orthic Humic Regosols among the most common. Thick, dark colored Ah horizons high in organic matter are common to these soils. Other soils of HE1, Orthic Dystric Brunisols, Orthic Eutric Brunisols, and Orthic Regosols, are similar respectively to the Ecosite concept soils listed above but have thinner Ah horizons. Turbic phases of soils are common with both cryoturbation and solifluction (processes often responsible for the Regosolic soils). Sombric and Dystric Brunisols are associated with Residuum A while Melanic and Eutric Brunisols occur on Residuum B. A pedon from Pipestone Pass in Banff sampled to represent soils of HE1 is presented in Table 219, and shown in Color Plate 31. Plate 127 shows this sample site.

This pedon is an Orthic Dystric Brunisol, lithic and turbic phases, and the variable depth (6-12 cm) of the Ah horizon indicates it intergrades to Orthic Sombric Brunisol soils. It has developed in an Eolian material B veneer deposited over Residuum A which was derived from a pebble conglomerate bed within the Miette Group strata, rather than from the more typical slates and shales. The Bhfy horizon probably contains some altered, medium textured eolian material (Eolian material B). This same horizon has a high organic carbon content.

Other soils may occur in the mosaic. More extreme cryoturbation or solifluction may produce turbic phases of Cumulic Regosols. Podzolic B horizons occur occasionally, especially on stable sites in western Banff and southwestern Jasper where Eolian material B is incorporated into the solum. Areas of nonsoil occur on upper slopes and on irregular surfaces with varying lithology.

Soils are well drained in general but depressions in the bedrock surface can trap water, causing poor drainage locally. These areas often have pronounced frost hummocks. In spring, even the well drained soils are often temporarily saturated above the frost table and are unstable until further thaw allows internal drainage to remove excess water.

Vegetation

Vegetation is most commonly the mountain avens-snow willow-moss campion (H1) v.t. It by far dominates HE1 tracts on the eastern

Table 219 Pedon (Alberta 1977 No. 129) description of an Orthic Dystric Brunisol, lithic and turbic pahse, of the HE1 Ecosite.

CLASSIFICATION: CANADIAN SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: HE1.

LOCATION: MILITARY GRID REF. 11 UBE 4980 2830; NTS MAP AREA 82N 9W.

CLIMATE: 2300 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE.

VEGETATION: VTHHKI-LS#.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.S.S), EOLIAN; PARENT MATERIAL 2: CHEMICAL AND PHYSICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.S.S), RESIDUAL, CONGLOMERATE; DEPTH TO BEDROCK IS 0.5 M; LANDFORM CLASSIFICATION: BEDROCK, DEFLATED, RIDGED; SLOPE: 5% COMPLEX SLOPE OF CLASS 4 (6-9%), FACING SOUTHWEST, SITE AT CREST POSITION, 10 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; EXCESSIVELY ROCKY.

SPECIAL NOTES: [illegible]

LFH: 1 TO 0 CM, RANGE 1 TO 2 CM; HORIZON MOIST; WAVY, ABRUPT HORIZON BOUNDARY.

AH: 0 TO 8 CM, RANGE 6 TO 12 CM; HORIZON MOIST; MATRIX MOIST 5YR 2.5/1, MATRIX MOIST 7.5YR 4/2; LOAM; WEAK, VERY FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE, RANDOM ROOTS; COMMON, VERY FINE AND FINE PORES; GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BHFY: 8 TO 13 CM, RANGE 6 TO 8 CM; HORIZON MOIST; MATRIX MOIST 5YR 3/3; SILT LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY WEAK, FINE, GRANULAR SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE, RANDOM ROOTS; COMMON, FINE AND MEDIUM PORES; GRAVELLY COARSE FRAGMENTS; BROKEN, ABRUPT HORIZON BOUNDARY.

2BM: 13 TO 33 CM, RANGE 18 TO 20 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/6; LOAM; WEAK TO MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; FEW, FINE, RANDOM ROOTS; 30% AND 30% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2BC: 33 TO 36 CM, RANGE 2 TO 5 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/4; COARSE SANDY LOAM AND LOAM; FRIABLE CONSISTENCE; 30% AND 50% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

R: 36 CM

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LFH								
AH	6.4	6.40	22.4		6.6	1.9	0.1	0.3
BHFY	6.5	7.60	30.9		2.3	0.3	0.1	0.2
2BM	6.2	0.90	13.6		9.8	0.7	-.1	0.3
2BC								
R								

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2
LFH				
AH				
BHFY	0.6		0.9	
2BM	0.3		0.1	
2BC				
R				

PHYSICAL DATA

ENGINEERING

HORIZON	ATTERBERG PLASTIC LIMIT (%)	ATTERBERG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LFH								
AH								
BHFY								
2BM	22.9	38.8		22.9	1.6		24	8
2BC								
R								

PHYSICAL DATA (SURVEY)

PARTICLE SIZE ANALYSIS

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LFH										43		43	14	2
AH										22		44	12	1
BHFY										47		41	12	4
2BM	99	84	76	63										
2BC														
R														

side of the parks. Toward the Continental Divide H1 still is prevalent but areas of white mountain heather-mountain avens-snow willow (L4) and heather-everlasting (L5) become common. A vegetation plot sampled within 1 km of the pedon described in Table 219 and occurring on similar residuum and the same soil Subgroup and phase is presented in Table 220. This plot occurs in a landscape similar to the above pedon sample site shown in Plate 127. It is classified as an L4 v.t. which is an accessory v.t. on HE1. This L4 v.t. plot represents a moderately deep snowbed community and occurs in a mosaic with the H1 v.t. that occurs on more exposed shallower snow sites.

Table 220 Stand (PA7119) illustrating white mountain heather-mountain avens-snow willow (L4), an accessory v.t. of the HE1 Ecosite.

	HERB-DWARF SHRUB LAYER
Arenaria obtusiloba	.5
Carex atrosquama	.5
Cassiope tetragona	35
Castilleja occidentalis	.5
Draba lonchocarpa	.5
Dryas octopetala	15
Erigeron aureus	01
Festuca brachyphylla	.5
Haplopappus lyallii	.5
Luzula spicata	.5
Phyllodoce glanduliflora	02
Potentilla diversifolia	.5
Salix nivalis	05
Saxifraga bronchialis	.5
Silene acaulis	01
Selaginella densa	.5
	BRYOID LAYER
Cetraria cucullata	01
Cetraria islandica	01
Cetraria laevigata	.5
Cladonia cornuta	.5
Dactylina arctica	.5
Dactylina ramulosa	.5
Dicranum scoparium	.5
Hypnum revolutum	.5
Paraleucobryum enerve	.5
Polytrichum juniperinum	.5
Barbilophozia hatcheri	.5
Rhizocarpon geographicum	01

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Other v.t.s occurring less commonly include black alpine sedge-everlasting (H2) on moist, deep snowbed sites close to the Continental Divide and arctic willow-cinquefoil (L7) on moist, moderately deep snowbed sites. Sparcely vegetated (<20% cover) portions occur in severely cryoturbated and soliflucted areas on turbic Regosolic soils. Saxicolous lichen (H12) occurs at high elevations, especially on noncalcareous, medium textured residuum (Residuum A) and also on areas of nonsoil.

Discussion

Because of the diversity encompassed by HE1, it resembles most other Alpine Ecosites in some respects. Steeper soliflucted slopes on Residuum A resemble the colluvial Redoubt 1 (RD1) while on Residuum B they resemble the colluvial Bow Summit 1 (BS1). The colluvial deposits are usually deeper over bedrock than HE1, especially on lower slopes, and form steeper, more linear slopes than HE1. Quartzite and quartz sandstone is not highly jointed in the parks, so noncalcareous, coarse textured residuum resembling the colluvium of Tekarra 1 (TK1) seldom develops. Residuum A tracts mapped as HE1 resemble Jonas 1 with thin till and dominantly lithic soils (JN1X) but are distinguished by the residual versus till genetic materials. Similarly, HE1 on Residuum B resembles Molar Pass 1 on tracts with thin till and lithic soils (MP1X). The HE1 Ecosite, with noncalcareous, coarse textured residuum resembling the till of Eiffel 1 (EF1X tracts) does not commonly develop. The HE1 Ecosite is the Alpine counterpart of the Upper Subalpine Ecosite Copper 1 (CP1). Also, CP1 usually only occurs on Residuum A found on failed bedrock. The HE2 Ecosite occurs in a different structural, stratigraphic and topographic setting than HE1. Ecosite characteristics of each are outlined in Table 218.

The HE1 Ecosite makes up a greater percentage of the vegetated Alpine Ecoregion than its residual counterparts do in lower Ecoregions because glaciation stripped away most pre-existing residuum in the Subalpine and Montane.

HE2 - HEATHER 2 ECOSITE

Ecosite Concept

The Alpine Ecosite, HE2, occurs dominantly as ridged bedrock outcrops with a mosaic of thin surficial veneers. Because of the extensive outcrops, most areas are nonsoil (<10 cm of unconsolidated material over bedrock) and unvegetated (scattered vegetation, with cover <20%). Where soils occur, they are lithic phases of Orthic Melanic Brunisols and Orthic Humic Regosols. Vegetation is more extensive than soil, as it develops on both soil and nonsoil areas and is most frequently identified as the mountain avens-snow willow-moss campion (H1) v.t.

Heather 2 occurs at high elevations on cirque floors that are generally carved into resistant carbonate strata of the upper stratigraphic column of the Main Ranges. Thus, this Ecosite is mainly distributed in the central to western side of the parks. Extensive examples are mapped just north of Mount Eisenhower in Banff, and one of these is shown from a distance of a few kilometres in Plate 128.

Geomorphology

The HE2 Ecosite occurs on ridged bedrock outcrops with a sporadic regolith veneer. This regolith is a mosaic of eolian, morainal, fluvial, colluvial, and residual materials or mixtures thereof.

Bedrock controls many of the characteristics of HE2. Most tracts occur on calcareous strata of the upper stratigraphic column of the Main Ranges in central and western Banff and Jasper (Fig. 4). Outcrop lithology is dominantly dense, massive, resistant limestone and dolomitic limestone of early to middle Cambrian age. Geologically associated units are the Lynx Group, and the Cathedral and Eldon Formations. Occasionally, other Paleozoics with massive carbonate members, such as the Palliser Formation, underlie HE2. Surfaces of this Ecosite often closely parallel the characteristically gently dipping bedding planes of these Main Ranges Formations (Plate 128). Slopes are commonly 5 to 30% complex. Where the ground surface cuts across steeply dipping bedding planes of varying lithology, more rugged landscapes with complex slopes between 30 and 70% occur (Plate 129). Bedrock is the dominant feature of HE2. The dense, massive, carbonate bedrock in the Main Ranges structural setting is less affected by deformation and jointing than most other rocks in the parks. Thus, the scouring agents of glaciation removed and carried away less resistant overlying rock, leaving roughly planar (bedding planes), debris-free surfaces. The HE2 Ecosite is often found in hanging cirques because of this resistant rock (Plate 128). Sporadic veneers of calcareous, medium textured till (Till C) are the only vestige of glacial debris, indicating that in their later stages, glaciers were eroding very little of the resistant underlying bedrock. Widely spaced jointing is not conducive to physical weathering while chemical weathering is slow on the carbonates as evidenced by fresh surfaces with still visible glacial striations in areas where the ice front retreated several thousands of years ago. Therefore, calcareous, medium textured residuum (Residuum B) is not abundant. Local veneers of calcareous, medium textured colluvium (Colluvium C) occur on steeper slopes. Runoff water often accumulates on the impermeable bedrock surface and calcareous, coarse, stratified fluvial material (Fluvial material B) is deposited on stream courses. Finally, thin accumulations of altered, medium textured eolian material (Eolian material B) occur in areas protected from erosion. All of these sporadic veneers can be affected by cryoturbation, and on steeper slopes, by solifluction. Occasionally, HE2 was also mapped on areas of noncalcareous Gog Group strata, particularly where the massive quartzites resulted in a similar geomorphic process to that described above.

Soils

Bedrock outcrop dominates HE2, so a great majority of the area of any tract is nonsoil. Where soils do occur (>10 cm unconsolidated material), they are lithic phases of Orthic Melanic Brunisols and Orthic Humic Regosols. Thick dark colored Ah horizons, high in organic matter, are common to these soils. Where this depth is less than 10 cm, soils are Orthic Eutric Brunisols and Orthic Regosols, respectively. The Brunisolic soils often have calcareous B horizons, indicating they are similar to the Regosolic soils. Table 221 describes an Orthic Regosol from the head of the valley containing Brazeau Lake in Jasper and illustrates the soils of HE2. The landscape in the vicinity of this pedon is shown in Plate 129.

The residual parent material at this site has been modified by colluviation. Depth of the Ah horizon (8 cm) indicates that this Orthic Regosol is intergrading to an Orthic Humic Regosol.

Table 221 Pedon (Alberta 1976 No. 999) description of an Orthic Regosol, lithic phase, of the HE2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC REGOSOL. SOIL MAP UNIT: NOTATION: HE2.

LOCATION: MILITARY GRID REF. 11 UMJ 0190 2190; NTS MAP AREA 83C 11.

CLIMATE: 2370 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS POOR RELEVANCE TO THE SOIL SITE.

VEGETATION: VPN=JC&0S1*VTN=H1*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), COLLUVIAL. LIMESTONE AND DOLOMITE; DEPTH TO BEDROCK IS 0.3 M; LANDFORM CLASSIFICATION: COLLUVIAL, SOLIFLUCTED, VENEER; SLOPE: 16% COMPLEX SLOPE OF CLASS 6 (16-30%), FACING SOUTH; SITE AT UPPER SLOPE POSITION; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, SEEPAGE ABSENT; EXCEEDINGLY STONY; EXCEEDINGLY ROCKY.

SPECIAL NOTES: SSN=RM&042*APH=010-112*RLU=15*LFH=CV/RR-3*PCF=4AS,2AC,1ST(1)3AG,5AC,1ST(2)*PEDON NOT SAMPLED*

AH: 0 TO 8 CM; MATRIX MOIST 10YR 3/2; GRAVELLY SILT LOAM; ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CK: 8 TO 30 CM; SILT LOAM; STRONG EFFERVESCENCE; 40% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; ABRUPT HORIZON BOUNDARY.

R: 30 CM

Except in local fluvial situations, soils are rapidly to well drained. Fluvial areas are dominantly Rego Gleysols. Turbic phases are common, a result of either cryoturbation or solifluction.

Vegetation

A majority of HE2 is unvegetated (scattered vegetation with <20% cover) because of the dominance of bedrock outcrop. Where vegetation occurs it is usually the mountain avens-snow willow-moss campion (H1) v.t. Table 222 describes an H1 v.t. sampled at the same site as the pedon in Table 221 to illustrate vegetated portions of HE2. The landscape in the vicinity of this plot is shown in Plate 129. Other v.t.s occur to a limited extent. Saxicolous lichen (H12) is the initial colonizer of some areas. Toward the Continental Divide, white mountain heather-mountain avens-snow willow (L4) and heather-everlasting (L5) occurs in sheltered areas that have soil. Poorly drained fluvial sites have a variety of v.t.s including willow/cinquefoil (S8), arctic willow-cinquefoil (L7) and occasionally cottongrass/moss (H10) and water sedge-beaked sedge (H11).

Vegetation is more extensive than soil, as it commonly develops on nonsoil as well as soil areas in HE2.

Discussion

Tracts of HE2 present a barren landscape broken by sporadic patches of tundra vegetation. Though of very limited extent, more lush vegetation is associated with watercourses (Plate 128). Thus, the limiting factors to biomass production onHE2 are soil and water as illustrated by Plate 130. Where these occur together, their significance to the ecology of this Ecosite is greater than their areal extent. Plate 130 illustrates a closeup view of a portion of the HE2 tract in Plate 128. The HE2 Ecosite is distinguished from the Miscellaneous Landscape Rockland (R) by having >20% soil and vegetation cover. The HE1 Ecosite occurs in a different structural, stratigraphic, and topographic setting than HE2. Ecosite characteristics of each are outlined in Table 218.

Table 222 Stand (JC6051) illustrating the mountain avens-snow willow-moss campion (H1) v.t. on vegetated portions of the HE2 Ecosite.

SHRUB LAYER	
Juniperus communis	01
Salix arctica	03
Salix barrattiana	30
HERB-DWARF SHRUB LAYER	
Agropyron latiglume	01
Anemone parviflora	.5
Antennaria lanata	.5
Aquilegia flavescens	.5
Artemisia norvegica	01
Astragalus alpinus	01
Astragalus spp.	.5
Carex scirpoidea	01
Cassiope tetragona	03
Draba oligosperma	.5
Dryas octopetala	35
Erigeron peregrinus	.5
Gentiana glauca	.5
Hedysarum alpinum	01
Mycsotis alpestris	.5
Phyllodoce glanduliflora	.5
Poa alpina	.5
Polygonum viviparum	.5
Potentilla diversifolia	.5
Salix nivalis	01
Solidago decumbens	01
Trisetum spicatum	.5
Equisetum scirpoides	01
Equisetum variegatum	.5
Selaginella dense	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

IB - ISHBEL ECOSECTION

The Ishbel (IB) Ecosection encompasses stabilized, hummocky landslide deposits that are variably textured and are derived from either noncalcareous or calcareous bedrock. It is characterized by Brunisolic and Regosolic soils associated with lodgepole pine forest, coniferous open forest, and Engelmann spruce-subalpine fir forest. The Ecosection occurs on mid to lower slope positions in the Lower Subalpine portion of the Subalpine Ecoregion in both parks.

Vegetation is the main criterion for separating the Ishbel Ecosection into three Ecosites (IB1, IB2 and IB3) as outlined in Table 223. Fig. 32 shows physiographic positions of the IB1, IB2 and IB3 Ecosites in relation to adjacent Ecosites.

Table 223 General features of the Ishbel (IB) Ecosites.

Ecosite	Landform	Soils	Vegetation
IB1	Landslide material; hummocky	Brunisolic	lodgepole pine forest
IB2	Landslide material; hummocky	Regosolic, Brunisolic	coniferous open forest
IB3	Landslide material; hummocky	Brunisolic	Engelmann spruce-subalpine fir forest

Table 224 Pedon (Alberta 1979 No. 70) description of an Eluviated Eutric Brunisol of the 1B1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: IB1.

LOCATION: MILITARY GRID REF. 11 UNJ 5245 5158; NTS MAP AREA 83C 13#.

CLIMATE: 1570 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 6 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=LC9184#VTN=C18#.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), COLLUVIAL, SEDIMENTARY; LAND ..PM CLASSIFICATION: INACTIVE COLLUVIAL, HUMMOCKY; SLOPE: 20% COMPLEX SLOPE OF CLASS 6 (16-30%), FACING SOUTH, SITE AT MIDDLE POSITION, MODERATELY ROUNDED MICROTOPOGRAPHY, 10 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; EXCEEDINGLY STONY; HUMMOCKY.

SPECIAL NOTES: SSN=NT9164#APH=010-105#RLU=15#PCF=1AG(2-3)2AG,1AC(4-6)3AG,3AC(5)4AG,3AC(7)5AG,4AC,3ST(8)#LFH=EV/CH#

LF: 3 TO 0 CM, RANGE 2 TO 5 CM; MATRIX DRY 10YR 3/1; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 11 CM, RANGE 9 TO 13 CM; MATRIX DRY 10YR 7/1, MATRIX MOIST 10YR 6/1; SILT LOAM; WEAK TO MODERATE, MEDIUM, PLATY STRUCTURE; WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE; SOFT CONSISTENCE; FEW, COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BM: 11 TO 16 CM, RANGE 4 TO 8 CM; MATRIX DRY 10YR 6/8, MATRIX MOIST 7.5YR 5/7; SILT LOAM; VERY WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; SOFT CONSISTENCE; FEW, MEDIUM AND COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

2BM: 16 TO 21 CM, RANGE 4 TO 6 CM; MATRIX DRY 7.5YR 4/4, MATRIX MOIST 10YR 5/3; CLAY LOAM; MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; SLIGHTLY HARD CONSISTENCE; FEW, FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

2BCK1: 21 TO 31 CM, RANGE 8 TO 11 CM; MATRIX DRY 10YR 5/3, MATRIX MOIST 10YR 4/3; SILT LOAM; WEAK, FINE TO MEDIUM, GRANULAR STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; MODERATE EFFERVESCENCE; BROKEN, CLEAR HORIZON BOUNDARY.

2BCK2: 31 TO 100 CM, RANGE 0 TO 69 CM; MATRIX DRY 10YR 4/3, MATRIX MOIST 10YR 4/3; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; STRONG EFFERVESCENCE; BROKEN, CLEAR HORIZON BOUNDARY.

2CK1: 31 TO 51 CM, RANGE 0 TO 20 CM; MATRIX DRY 10YR 6/3, MATRIX MOIST 10YR 5/3; SILT LOAM; WEAK, FINE TO MEDIUM, GRANULAR STRUCTURE; SOFT CONSISTENCE; FEW, MICRO AND VERY FINE ROOTS; STRONG EFFERVESCENCE; WAVY, GRADUAL HORIZON BOUNDARY.

2CK2: 51 TO 100 CM; MATRIX DRY 10YR 5/3, MATRIX DRY 10YR 6/3; GRAVELLY SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; FEW, FINE AND MEDIUM ROOTS; STRONG EFFERVESCENCE.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.6	45.80							
AE	5.7	4.00		23.4		11.4	2.3	0.1	0.2
BM	6.4	3.10		40.1		18.6	5.8	0.1	0.2
2BM	6.9	1.00	5.9						
2BCK1	7.3		80.6						
2BCK2	7.3		66.2						
2CK1	7.6		97.3						
2CK2	7.8		87.3						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	0.1		0.1	
2BM	0.1		-.1	
2BCK1				
2BCK2				
2CK1				
2CK2				

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF								3	13	16		77	7	
AE														
BM					4	9	11	11	10	45		50	5	
2BM					1	5	10	7	5	28		37	35	
2BCK1					1	1	2	11	19	34		56	10	
2BCK2					3	5	5	6	8	27		65	8	
2CK1					10	7	5	8	11	41		57	2	
2CK2	99	59	37	31	13	9	6	7	10	45		51	4	

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AE								
BM								
2BM								
2BCK1								
2BCK2								
2CK1								
2CK2							12	03

IB1 - ISHBEL 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, IB1, occurs on hummocky landslide deposits (Landslide material) that are variably textured and derived from either calcareous or noncalcareous bedrock. The IB1 Ecosite is dominated by well drained Orthic and Eluviated Eutric Brunisols, and Eluviated Dystric Brunisols associated with the lodgepole pine/buffaloberry/grouseberry (C18), lodgepole pine/buffaloberry/twinflower (C19), and lodgepole pine/Labrador tea (C29) v.t.s.

Geomorphology

The IB1 Ecosite encompasses stabilized landslides (Landslide material) with hummocky surface expression. The landslide deposits often overlie inclined morainal and bedrock slopes on valley walls. These postglacial deposits range from medium acid to extremely calcareous in reaction and, texturally, from silt loam to loamy sand. They have a high content of variable sized angular and subangular coarse fragments. Surfaces are very stony and bouldery. Discontinuous veneers of altered, medium textured eolian material (Eolian material B) that may significantly increase the surficial fine earth fraction occur on some tracts, especially in western Banff and southwestern Jasper. Surfaces are dominantly irregular with a wide range of complex slopes.

Soils

The IB1 Ecosite is dominated by well drained Orthic and Eluviated Eutric Brunisols, and Eluviated Dystric Brunisols. These soils develop on landslide material that reflects the nature of the bedrock from which it has been derived. Orthic and Eluviated Eutric Brunisols are soils that develop on the calcareous landslides and are primarily medium textured. Eluviated Dystric Brunisols develop on the less common noncalcareous landslide deposits with textures ranging from medium to coarse. These variably textured soils are occasionally fragmental at depth. A pedon described in Table 224 and shown in Color Plate 32 illustrates the soil of the IB1 Ecosite. The Ae and Bm horizons of this pedon are developed in the eolian veneer. The IIBm horizon in this pedon has more clay than the Ae but lacks clay films. This pedon was sampled on a tract of IB1 2.5 km south of Medicine Lake in Jasper.

Vegetation

The IB1 Ecosite is dominated by the lodgepole pine/buffaloberry/grouseberry (C18), lodgepole pine/buffaloberry/twinflower (C19), and lodgepole pine/Labrador tea (C29) v.t.s. The closely related C18 and C19 occur on tracts of IB1 in both parks. The C29 v.t. primarily occurs on IB1 in Jasper. Minor amounts of the Douglas fir/hairy wild rye (C1) v.t. occur near the Montane boundary on a tract of IB1 mapped between Johnston Creek and Hillsdale in Banff. The white spruce/juniper/bearberry (O17) v.t. occurs on tracts of IB1 in patches that are too small to be mapped as Ishbel 2 (IB2). A vegetation plot description in Table 225 and shown in Plate 131 illustrates the C18 v.t. on IB1 and represents the vegetation of the sampled pedon described in Table 224.

Table 225 Stand (LC9186) illustrating the lodgepole pine/buffaloberry/grouseberry (C18) v.t. of the IB1 Ecosite.

TREE LAYER	
Pinus contorta	45
TALL SHRUB LAYER	
Picea glauca	15
SHRUB LAYER	
Ledum groenlandicum	05
Menziesia glabella	.5
Picea glauca	05
Salix spp.	.5
Shepherdia canadensis	25
HERB-DWARF SHRUB LAYER	
Elymus innovatus	12
Epilobium angustifolium	02
Linnaea borealis	10
Picea glauca	.5
Pyrola secunda	01
Rosa acicularis	02
Vaccinium membranaceum	02
Vaccinium scoparium	18
Vaccinium vitis-idaea	03
BRYOID LAYER	
Cladonia arbuscula	02
Cladonia ecmocyna	01
Cladonia furcata	01
Cladonia gonecha	.5
Cladonia multiformis	01
Hylocomium splendens	10
Peltigera aphthosa	10
Pleurozium schreberi	20
Ptilium crista-castrensis	25
EPIPHYTES	
Bryoria fuscescens	.5
Cetraria pinastri	.5
Hypogymnia physodes	.5
Letharia vulpina	.5
Usnea spp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The IB1 Ecosite is separated from the other Ecosites in the IB Ecosection primarily on vegetational differences as outlined in Table 223. The IB1 Ecosite most resembles the

BZ2 Ecosite in terms of similar surface expression, soils, and vegetation. The BZ2 Ecosite is separated because it has residual genetic material. The IB1 Ecosite may also resemble failed till slopes dominated by lodgepole pine v.t.s. but again can be distinguished by its residual genetic material.

IB2 - ISHBEL 2 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, IB2, occurs on hummocky landslide deposits (Landslide material) that are variably textured and derived from either calcareous or noncalcareous bedrock. The IB2 Ecosite is dominated by rapidly drained Orthic Regosols, Eluviated Eutric Brunisols, and Eluviated Dystric Brunisols associated with the Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) and white spruce/juniper/bearberry (O17) v.t.s.

Geomorphology

The IB2 Ecosite encompasses stabilized landslides (Landslide material) with hummocky surface expression. The landslides often overlie inclined morainal and bedrock slopes on valley walls. These postglacial deposits range from medium acid to extremely calcareous in reaction and, texturally, from silt loam to loamy sand. They have a high content of variably sized angular and subangular coarse fragments and are often fragmental at depth. Very stony and bouldery surfaces are typical. Hummocky surface expression results in a wide range of complex slopes.

Soils

Rapidly drained Orthic Regosols are more common than Orthic Eutric Brunisols and Eluviated Dystric Brunisols as the dominant soils on IB2. These soils develop on landslide material that reflects the nature of the bedrock from which it has been derived. Orthic Eutric Brunisols develop on the more abundant calcareous landslides and Eluviated Dystric Brunisols develop on deposits derived from noncalcareous bedrock. Eluvial (Ae) horizons are more common on noncalcareous material and Orthic Regosols are less abundant. A pedon described in Table 226 and shown in Color Plate 33 illustrates the soil of IB2. This pedon was described on a landslide in the Dormer River valley northwest of Otuskwan Peak in Banff.

Vegetation

The IB2 Ecosite is dominated by the Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) and white spruce/juniper/bearberry (O17) v.t.s. Open variants of the lodgepole pine/juniper/bearberry (C3) v.t. and unvegetated areas occur as accessories. Minor amounts of lichen-covered colluvial rubble and patches of closed forest are present on IB2. Rubbly, blocky surfaces and lack of soil make tree establishment and growth difficult. A vegetation plot description in Table 227 and shown in Plate 47 illustrates the O17 v.t. on IB2 and represents the vegetation of the sampled pedon described in Table 226. The sampled plot differs from most O17 plots by having no *Arctostaphylos uva-ursi*.

Discussion

The IB2 Ecosite is separated from other Ecosites in the IB Ecosection primarily on vegetational differences as outlined in Table 223. Portions of IB2 most resemble the Miscellaneous Landscape Colluvial Landslide (CL). The latter is differentiated by having nonsoil or Regosols and <20% vegetation cover.

IB3 - ISHBEL 3 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, IB3, occurs on hummocky landslide deposits (Landslide material) that are variably textured and derived from either calcareous or noncalcareous bedrock. The IB3 Ecosite is dominated by well drained Orthic and Eluviated Eutric Brunisols, and Eluviated Dystric Brunisols associated with the Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) and Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) v.t.s.

Geomorphology

The IB3 Ecosite encompasses stabilized landslides (Landslide material) with hummocky surface expression. The landslide deposits often overlie inclined morainal and bedrock slopes on valley walls and are postglacial deposits that range from medium acid to extremely calcareous in reaction and, texturally, from silt loam to loamy sand. They have a high proportion of variably sized angular and subangular coarse fragments and are often fragmental at depth. Surfaces are very stony and bouldery. Surface expression is hummocky with a wide range of complex slopes. Discontinuous surficial veneers of altered, medium textured eolian material (Eolian material B) occur, especially in western Banff and southwestern Jasper, and often significantly increase the surficial fine earth fraction.

Soils

The IB3 Ecosite is dominated by well drained Orthic and Eluviated Eutric Brunisols and Eluviated Dystric Brunisols. These soils develop on landslide material that reflects the na-

Table 226 Pedon (Alberta 1978 No. 49) description of an Orthic Regosol of the IB2 Ecosite.

CLASSIFICATION: SUBGROUP: ORTHIC REGOSOL. SOIL MAP UNIT: NOTATION: IB2.

LOCATION: MILITARY GRID REF. 11 UNN 9890 1230; NTS MAP AREA 82O 12E.

CLIMATE: 1780 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 8 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JE8135+VTN=017/OPEN C3 COMPLEX+.

SOIL SITE: PARENT MATERIAL 1: SHATTERED WEATHERING, FRAGMENTAL (STONES,COBBLES AND GRAVEL) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), COLLUVIAL; LANDFORM CLASSIFICATION: INACTIVE COLLUVIAL, BLOCKY, HUMMOCKY; SLOPE: 45% COMPLEX SLOPE OF CLASS 8 (46-70%), FACING WEST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,300 M LONG; SOIL MOISTURE AND DRAINAGE: SEMIARID, RAPIDLY DRAINED, RAPIDLY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; EXCESSIVELY STONY; NONROCKY.

SPECIAL NOTES: SSN=BC8828+APN=01B-184+PCF+SAG,3AC,1ST(1)SAB,4AC,1SY(2)4AB,C,4ST(3)+LFH=CH+

AHK: 0 TO 6 CM, RANGE 4 TO 10 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/1, MATRIX MOIST 10YR 5/1; GRAVELLY COARSE SANDY LOAM; VERY WEAK, FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; HIGHLY POROUS; MODERATE EFFERVESCENCE; STRONGLY CALCAREOUS; ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

CK1: 6 TO 32 CM, RANGE 20 TO 28 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 3/2; GRAVELLY COARSE SANDY LOAM; STRUCTURELESS AND VERY WEAK, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; LOOSE AND VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND MEDIUM ROOTS; HIGHLY POROUS, COMMON, VERY FINE PORES; STRONG EFFERVESCENCE; STRONGLY CALCAREOUS; ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

CK2: 32 TO 50 CM, RANGE 15 TO 20 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/4, MATRIX MOIST 10YR 5/2; GRAVELLY LOAM; STRUCTURELESS AND VERY WEAK, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; LOOSE AND VERY FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; HIGHLY POROUS; STRONG EFFERVESCENCE; STRONGLY CALCAREOUS; ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
AHK	7.2	4.20	69.8
CK1	7.3	4.10	85.9
CK2	7.3	1.60	95.6

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS													
	% PASSING				% OF SAMPLE									
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
AHK					19	23	12	8	5	67		27	6	
CK1					14	20	11	7	7	58		37	5	
CK2	99	37	22	20	4	8	8	7	11	38		47	15	

PHYSICAL DATA

	MOISTURE STATUS (%)					ENGINEERING							
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AHK		10.6	11.2										
CK1													
CK2		20.0	14.7									11	03

ture of the bedrock from which it has been derived. Orthic and Eluviated Eutric Brunisols develop on the more abundant calcareous landslides. Eluviated Dystric Brunisols develop on landslide deposits derived from noncalcareous bedrock. Well developed soils occur on IB3, possibly due to old surfaces and the accumulation of significant amounts of altered, medium textured eolian material (Eolian material B). A pedon described in Table 228 and shown in Color Plate 34 illustrates the soil of IB3. This pedon has a Bhf horizon that is developed in the eolian veneer. This pedon was sampled on a landslide at the northeast end of Medicine Lake in Jasper.

Vegetation

A variety of Engelmann spruce-subalpine fir v.t.s occur on the IB3 Ecosite. These are best represented by the Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) and Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) v.t.s. The C21 v.t. more commonly occurs on noncalcareous landslide deposits. Engelmann spruce-subalpine fir/grouseberry (C15) and Engelmann spruce-subalpine fir/heather (O10) v.t.s occur in minor amounts near the Upper Subalpine boundary and in areas affected by cold air drainage. Other v.t.s occurring in minor amounts are the Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) and white spruce/buffaloberry/feathermoss (C37) v.t.s. The C37 v.t. occurs on a tract of IB3 in Redearth Creek valley in Banff. A vegetation plot description in Table 229 illustrates the C30 v.t. on IB3. This v.t. is shown in Plate 30 and represents the vegetation of the sampled pedon described in Table 228.

Table 228 Pedon (Alberta 1978 No. 26) description of an Eluviated Eutric Brunisol of the 1B3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: IB3.

LOCATION: MILITARY GRID REF. 11 UMJ 4550 8635; NTS MAP AREA 83C 13*.

CLIMATE: 1480 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS MODERATE RELEVANCE TO THE SOIL SITE.

VEGETATION: VPN=JM8114* VTN=C30*.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN; PARENT MATERIAL 2: UNSPECIFIED WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (5-40% CACO3), COLLUVIAL, SHALE AND LIMESTONE; LANDFORM CLASSIFICATION: COLLUVIAL, HUMMOCKY AND SLOPING; SLOPE: 26% SIMPLE SLOPE OF CLASS 6 (16-30%), FACING NORTH, SITE AT MIDDLE POSITION; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY.

SPECIAL NOTES: SSN=DA8089*APN=810-103*PCF=1SH(2-4)2BM,2AC(5)3SH,1AC(6-7)2BM HORIZON NOT SAMPLED*LFH=CH,I*

LF: 14 TO 0 CM, RANGE 10 TO 14 CM; HORIZON MOIST; FEW AND ABUNDANT, FINE AND MEDIUM AND COARSE, HORIZONTAL ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 3 CM, RANGE 1 TO 5 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/1; SILT LOAM; VERY WEAK, VERY FINE TO FINE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW AND PLENTIFUL, FINE AND MEDIUM AND COARSE, HORIZONTAL ROOTS; 10% SHALY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

BHF: 3 TO 8 CM, RANGE 3 TO 7 CM; HORIZON MOIST; MATRIX MOIST 2.5YR 3/6, MATRIX MOIST 2.5YR 4/6; SILT LOAM; WEAK, FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; FEW AND PLENTIFUL, FINE AND MEDIUM AND COARSE, HORIZONTAL ROOTS; 10% SHALY COARSE FRAGMENTS; SMOOTH, CLEAR HORIZON BOUNDARY.

2BM: 8 TO 11 CM, RANGE 1 TO 5 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/4; SILTY CLAY LOAM; WEAK TO MODERATE, FINE, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; FEW, FINE AND MEDIUM, VERTICAL ROOTS; 10% SHALY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2BCK: 11 TO 16 CM, RANGE 0 TO 10 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/3; SILTY CLAY LOAM; MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, VERY FINE AND FINE, VERTICAL ROOTS; MODERATE EFFERVESCENCE; VERY STRONGLY CALCAREOUS; 10% SHALY AND ANGULAR COBBLY COARSE FRAGMENTS; BROKEN, GRADUAL HORIZON BOUNDARY.

2CK1: 16 TO 41 CM, RANGE 21 TO 28 CM; HORIZON MOIST; MATRIX MOIST 2.5Y 6/2; SILTY CLAY LOAM; STRUCTURELESS, GRANULAR STRUCTURE; MODERATE TO STRONG, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE PSEUDO; FRIABLE CONSISTENCE; VERY FEW, VERY FINE, VERTICAL ROOTS; COMMON, THIN CLAY FILMS IN MANY VOIDS/CHANNELS AND ON SOME VERTICAL AND HORIZONTAL PED FACES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 20% SHALY AND ANGULAR COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2CK2: 41 TO 70 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; MODERATE, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE PSEUDO; FRIABLE CONSISTENCE; COMMON, THIN CLAY FILMS IN MANY VOIDS/CHANNELS AND ON SOME VERTICAL AND HORIZONTAL PED FACES; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; 20% SHALY AND ANGULAR COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	3.9	46.00							
AE	3.7	2.20		18.5		3.4	0.4	0.2	0.2
BHF	5.4	7.70		72.7		25.9	0.6	0.7	0.2
2BM									
2BCK	7.0		32.2						
2CK1	7.2		47.8						
2CK2	7.8		28.5						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BHF	0.4		0.6	
2BM				
2BCK				
2CK1				
2CK2				

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS: % PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE										17		73	10	
BHF										17		67	16	
2BM														
2BCK										10		52	38	
2CK1	99			88						11		55	34	
2CK2	99			41						24		50	26	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE		36.6	10.2										
BHF													
2BM													
2BCK													
2CK1		25.5	14.2			25.0	35.0					48	09
2CK2		21.7	10.5			18.0	30.0		17.0	1.7		24	

Table 227 Stand (SJ9123) illustrating the white spruce/juniper/bearberry (017) v.t. of the IB2 Ecosite.

TREE LAYER	
Abies lasiocarpa	02
Picea glauca	05
TALL SHRUB LAYER	
Abies lasiocarpa	05
Picea glauca	04
SHRUB LAYER	
Abies lasiocarpa	10
Juniperus communis	15
Ledum groenlandicum	.5
Picea glauca	05
Ribes oxyacanthoides	02
Rosa acicularis	02
Rubus strigosus	.5
Shepherdia canadensis	01
HERB-DWARF SHRUB LAYER	
Arnica cordifolia	.5
Elymus innovatus	01
Linnaea borealis	01
Vaccinium caespitosum	.5
Vaccinium scoparium	.5
Vaccinium vitis-idaea	01
BRYOID LAYER	
Barbilophozia lycopodioides	02
Caloplaca sinapisperma	.5
Cladonia arbuscula	01
Cladonia cenotea	.5
Cladonia coccifera	.5
Cladonia cornuta	.5
Cladonia gonecha	.5
Cladonia pyxidata	.5
Cynodontium strumiferum	.5
Dicranum brevifolium	01
Dicranum muehlenbeckii	01
Dicranum scoparium	03
Hylocomium splendens	05
Lecidea hypocrita	08
Lophozia floerkii	.5
Nephroma expallidum	.5
Parmelia chlorochroa	.5
Peltigera aphthosa	.5
Peltigera canina	.5
Pleurozium schreberi	.5
Ptilidium pulcherrimum	.5
Ptilium crista-castrensis	.5
Physconia muscigena	.5
Rhizocarpon disporum	.5
Rhizocarpon geographicum	.5
Rinodina roscida	.5
Stereocaulon alpinum	.5
Stereocaulon pileatum	.5
Umbilicaria sp.	.5
EPIPHYTES	
Bryoria fremontii	.5
Cetraria pinastri	.5
Letharia vulpina	.5
Parmelia sulcata	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Table 229 Stand (JM8114) illustrating the Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) v.t. of the IB3 Ecosite.

TREE LAYER	
Abies lasiocarpa	11
Picea engelmannii	20
Picea mariana	01
TALL SHRUB LAYER	
Abies lasiocarpa	01
Picea engelmannii	01
Picea mariana	01
SHRUB LAYER	
Abies lasiocarpa	02
Ledum groenlandicum	60
Picea engelmannii	01
HERB-DWARF SHRUB LAYER	
Cornus canadensis	06
Elymus innovatus	.5
Linnaea borealis	.5
Listera cordata	.5
Pyrola secunda	01
Vaccinium membranaceum	02
Vaccinium scoparium	.5
Vaccinium vitis-idaea	02
Equisetum scirpoides	01
Lycopodium annotinum	.5
BRYOID LAYER	
Barbilophozia lycopodioides	.5
Cladonia arbuscula	.5
Cladonia cenotea	.5
Cladonia chlorophaea	.5
Cladonia coniocraea	.5
Cladonia cornuta	01
Cladonia ecmocyna	.5
Cladonia gonecha	.5
Cladonia gracilis	.5
Cladonia mitis	.5
Cladonia squamosa	.5
Cladonia spp.	.5
Dicranum acutifolium	.5
Dicranum muehlenbeckii	.5
Hylocomium splendens	65
Icmadophila ericetorum	.5
Ochrolechia androgyna	.5
Peltigera aphthosa	02
Peltigera canina	02
Peltigera malacea	.5
Pleurozium schreberi	15
Pohlia nutans	.5
Ptilidium pulcherrimum	.5
Ptilium crista-castrensis	15
Psoroma hypnorum	.5
Tetraplodon angustatus	.5
EPIPHYTES	
Alectoria sarmentosa	.5
Bryoria fremontii	.5
Cetraria pinastri	.5
Hypogymnia austerodes	.5
Hypogymnia physodes	.5
Letharia vulpina	.5
Parmelia sulcata	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5
Platismatia glauca	.5
Ramalina pollinaria	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The IB3 Ecosite is separated from other Ecosites of the IB Ecosection primarily on vegetational differences as outlined in Table 223. The IB3 Ecosite most resembles the Brazeau 1 (BZ1) Ecosite in terms of similar landform surface expression, soils, and vegetation but is distinguished because BZ1 has residual genetic material. The IB3 Ecosite may also resemble failed till slopes dominated by Engelmann spruce-subalpine fir v.t.s but the till genetic material provides the distinguishing criteria.

JN - JONAS ECOSECTION

The Jonas Ecosection encompasses morainal landforms comprised of noncalcareous, medium textured till (Till B) in the Alpine Ecoregion of Banff and Jasper. Jonas occurs most extensively in the Main Ranges in association with the Miette Group. It also occurs in the Front Ranges in association with noncalcareous Mesozoic (Jurassic and Lower Cretaceous) strata. Valley walls and shoulders, cirque basins, and cols are common physiographic positions in which JN occurs.

A soil pattern involving Dystric and Sombric Brunisols, and Podzols characterizes the soil component of JN. These well to moderately well drained, moderately to well developed soils reflect the acidic, medium textured parent material. Also humus accumulation in upper sola, and the distribution of veneers of altered, medium textured eolian material (Eolian material B) in cool, moist environments contribute to the distinct horizonation. The vegetation component is dominated by heath and mountain avens tundra, the heath tundra being more abundant. Table 230 summarizes the characteristics of the lone Jonas Ecosite (JN1). Fig. 39 shows the position of JN1 in relation to the Egypt (EG) and Sphinx (SX) Ecosites.

JN1 - JONAS 1 ECOSITE

Ecosite Concept

The Alpine Ecosite, JN1, occurs on morainal blankets and veneers consisting of noncalcareous, medium textured till (Till B) overlying inclined, hummocky, and ridged bedrock. A soil pattern relating to the amount of humus accumulation and presence of veneers of altered, medium textured eolian material (Eolian material B) characterizes JN1. Orthic Dystric Brunisols and Orthic Sombric Brunisols are dominant; Eluviated Dystric Brunisols and Orthic Ferro-Humic Podzols are subdominant. Vegetation cover is dominated by the heather-everlasting (L5) and mountain avens-snow willow-moss campion (H1) v.t.s with L5 being more abundant in most areas.

Geomorphology

The JN1 Ecosite is typified by morainal blankets and veneers overlying inclined, hummocky, or ridged bedrock. These moraines consist of noncalcareous, medium textured till (Till B). The low lime phase of Till B occurs in a few areas and is generally associated with Cambrian or younger weakly calcareous strata in central and eastern Banff and Jasper. Veneers of altered, medium textured eolian material (Eolian material B) occur extensively on JN1 tracts of western Banff and southwestern Jasper, sporadically elsewhere. Colluvium derived from till and/or fractured bedrock is found occasionally on steepest portions of the landscape.

Topographically, JN1 is typified by inclined slopes on valley walls and hummocky or ridged surfaces on valley shoulders, cirque basins, and cols. Slopes commonly range from 5 to 45%. Bedrock control of surface expression is characteristic. Failed slopes, including extinct rock glaciers and severely soliflucted slopes, are common (JN1F) and usually have hummocky surfaces that do not necessarily reflect underlying bedrock surfaces. Morainal veneers dominate on JN1X tracts. Bedrock outcrops occur sporadically but are abundant on JN1+R tracts. Patches of colluvium existing as blankets and veneers occur occasionally on the steepest terrain, particularly below bedrock escarpments.

Soils

A soil pattern in which Orthic Dystric and Orthic Sombric Brunisols are dominant and Eluviated Dystric Brunisols and Orthic Ferro-Humic Podzols subdominant characterizes JN1. Under the Alpine conditions, humus accumulation in upper sola is evident, often masking the effects of eluviation. Thus, the well to moderately well drained JN1 soils have varying thicknesses of Ah and/or Ahe horizons. Where veneers of Eolian material B are present, the soils often have Bhf or podzolic Bhf horizons above and Bm or BC horizons below the parent material disconformity.

Table 230 General features of the Jonas 1 (JN1) Ecosite.

Ecosite	Landform	Soils	Vegetation
JN1	Till B; blanket, veneer	Dystric and Sombric Brunisol > Ferro-Humic Podzol	heath tundra, mountain avens tundra

Table 231 Pedon (Alberta 1977 No. 128) description of an Eluviated Dystric Brunisol of the JN1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: JN1.

LOCATION: MILITARY GRID REF. 11 UNH 4880 2960; NTS MAP AREA 82N 9W.

CLIMATE: 2310 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS -2 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VTN=LS=.

SOIL SITE: PARENT MATERIAL 1: CHEMICAL AND PHYSICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.S.S), EOLIAN; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.S.S), MORAINAL (TILL), SHALE AND SLATE; PARENT MATERIAL 3: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.S.S), RESIDUAL, SHALE AND SLATE; DEPTH TO BEDROCK IS 1 M; LANDFORM CLASSIFICATION: MORAINAL AND UNCONSOLIDATED, SOLIFLUCTED, VENEER; SLOPE: 7% COMPLEX SLOPE OF CLASS 4 (6-9%), FACING SOUTH, SITE AT UPPER SLOPE POSITION, SLIGHTLY ROUNDED MICROTOPOGRAPHY,50 M LONG; SOIL MOISTURE AND DRAINAGE: MODERATELY WELL DRAINED, SLOWLY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE PRESENT; SLIGHTLY STONY; NONROCKY.

SPECIAL NOTES: 93N=BM7151=APH=010-209=BLU=15=59C=ST=RO=PCF=10R(1-2)2SR,3SL(3)3GR,1CB,4SL(4)6SL,2FL(5)=LFHHRV/BH-9=

AH: 0 TO 7 CM, RANGE 6 TO 8 CM; HORIZON MOIST; MATRIX MOIST 5YR 2.5/1; SILT LOAM; WEAK, VERY FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE, RANDOM ROOTS; COMMON, FINE AND MEDIUM PORES; GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BHF: 7 TO 10 CM, RANGE 1 TO 5 CM; HORIZON MOIST; MATRIX MOIST 5YR 3/3; SILT LOAM; VERY WEAK, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE, RANDOM ROOTS; COMMON, FINE AND MEDIUM PORES; GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

2BM: 10 TO 15 CM, RANGE 3 TO 12 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 4/4; GRAVELLY SILT LOAM; WEAK TO MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE, RANDOM ROOTS; FEW, FINE PORES; GRAVELLY AND SLATY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2BC: 15 TO 45 CM, RANGE 25 TO 35 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/3; GRAVELLY LOAM; STRUCTURELESS STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE, RANDOM ROOTS; GRAVELLY AND SLATY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

3BC: 45 TO 75 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/3, MATRIX MOIST 10YR 5/2; VERY GRAVELLY SANDY LOAM; FEW, MEDIUM, DISTINCT, 7.5YR 4/4 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; SLATY AND FLASSY COARSE FRAGMENTS; MEDIUM ACID 5.6-6.0 FIELD PH.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
AH	4.8	18.60	39.4		2.8	0.9	0.1	0.4
BHF	4.3	8.90	39.4		0.7	0.2	0.2	0.1
2BM	5.8	1.30	21.5		0.7	0.4	0.1	0.1
2BC	4.0		13.8		1.1	0.9	0.1	0.1
3BC	4.2		8.4		1.1	1.2	0.1	0.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
AH				
BHF	0.5		0.6	
2BM	0.4		0.1	
2BC				
3BC				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
AH														
BHF										7		75	18	5
2BM										9		80	11	2
2BC	99	82	53	42						8		73	19	3
3BC	99	95	79	70						42		47	11	2
										47		47	6	1

Soils with Bf or podzolic Bf horizons and Sombric Ferro-Humic Podzols also occur occasionally. Some JN1 soils have, in the lower sola and upper C horizons, clay films thought to be formed by pressure (e.g. freeze - thaw) rather than clay illuviation.

Lithic soil phases are associated with morainal veneers. These dominate on JN1X tracts. Turbic phases of JN1 soils, produced primarily by solifluction, are common, particularly on moderately well, imperfectly, and poorly drained localities with seepage. Physical thickening, rearrangement, mixing, and/or disruption of upper sola horizons are manifestations of the solifluction process. Regosolic soils are found on severely solifluctedand colluviated sites. Imperfectly to poorly drained gleyed Brunisols (especially Gleyed Dystric Brunisols), gleyed Podzols, and Gleysols often occur locally. A few JN1 tracts located on valley floors, usually adjacent to Upper Subalpine Sphinx 1 or 3 (SX1, SX3) tracts, have an uncharacteristically high proportion of imperfectly drained, seepage affected soils.

A pedon illustrating Orthic Dystric Brunisols of JN1 is described in Table 231 and is shown in Color Plate 35. Plate 132 shows the sample site. The till parent material is distinguishable from the underlying noncalcareous, medium textured residuum (Residuum A) in this profile by the abundance, shape, and orientation of coarse fragments. Seepage occurs episodically here and is probably related to the shallowness of unconsolidated materials.

Adjacent pedons better display the effects of solifluction than does this pedon.

Vegetation

The vegetation of JN1 is dominated by the heather-everlasting (L5) and mountain avens-snow willow-moss campion (H1) v.t.s. The L5 v.t. is usually more abundant, particularly in the high snowfall areas along the Continental Divide whereas H1 occurs on some of the more exposed, wind-swept, ridge and hummock crests in western Banff and Jasper. Eastward, H1 becomes increasingly more abundant. On some of the more severely soliflucted, exposed JN1 tracts in eastern Banff and Jasper, H1 is more abundant than L5. A mosaic of vegetated and nonvegetated patches also occur where solifluction and cryoturbation is severe. Accessory v.t.s are white mountain heather-mountain avens-snow willow (L4) and black alpine sedge-everlasting (H2). Both occur in late snow lie localities. The H2 v.t. often occurs in small nivation hollows where snow lies latest and also on meltwater runoff localities. Seepage affected sites have moist to wet v.t.s such as arctic willow-cinquefoil (L7), mountain marigold-globeflower (H9), and fleabane-valerian (H16). Up to 20% krummholz and tree islands are included along lower boundaries of some JN1 tracts. A stand illustrating L5 on JN1 is described in Table 232. This stand is located < 10 km southeast of the pedon sample site.

Discussion

In terms of physiographic position, landform surface expression, and vegetation cover, JN1 resembles the Molar Pass 1 (MP1) and Eiffel 1 (EF1) Ecosites. However, in contrast to JN1 which occurs on Till B, MP1 occurs on morainal landforms consisting of calcareous, medium textured till (Till C); EF1 occurs on noncalcareous, coarse textured till (Till A). Also MP1 has Eutric and Melanic rather than Dystric and Sombric Brunisols. Soils on EF1 are similar to JN1 soils except that stronger profile development results in Eluviated Dystric Brunisols and Orthic Ferro-Humic Podzols being more abundant on EF1. Covarying vegetation distinctions include mountain avens-snow willow-moss campion (H1) being more abundant on MP1 than on JN1, and H1 occurring only occasionally, as an accessory v.t., on EF1. The Egypt 4 (EG4) Ecosite is the Upper Subalpine counterpart of JN1.

Table 232 Stand (PA7143) illustrating the heather-everlasting (L5) v.t. of the JN1 Ecosite.

	HERB-DWARF SHRUB LAYER
Anemone occidentalis	01
Antennaria lanata	20
Arnica mollis	.5
Carex phaeocephala	02
Erigeron peregrinus	03
Luzula wahlenbergii	.5
Myosotis alpestris	.5
Phleum alpinum	01
Phyllodoce glanduliflora	30
Polygonum viviparum	.5
Ranunculus eschscholtzii	.5
Salix arctica	15
Trisetum spicatum	02
Vaccinium scoparium	.5
	BRYOID LAYER
Barbilophozia hatcheri	01
Barbilophozia lycopodioides	01
Brachythecium spp.	05
Cetraria islandica	02
Cladonia ecmocyna	10
Desmatodon latifolius	.5
Dicranum scoparium	10
Peltigera spp.	.5
Pogonatum alpinum	05

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

KA - KATHERINE ECOSECTION

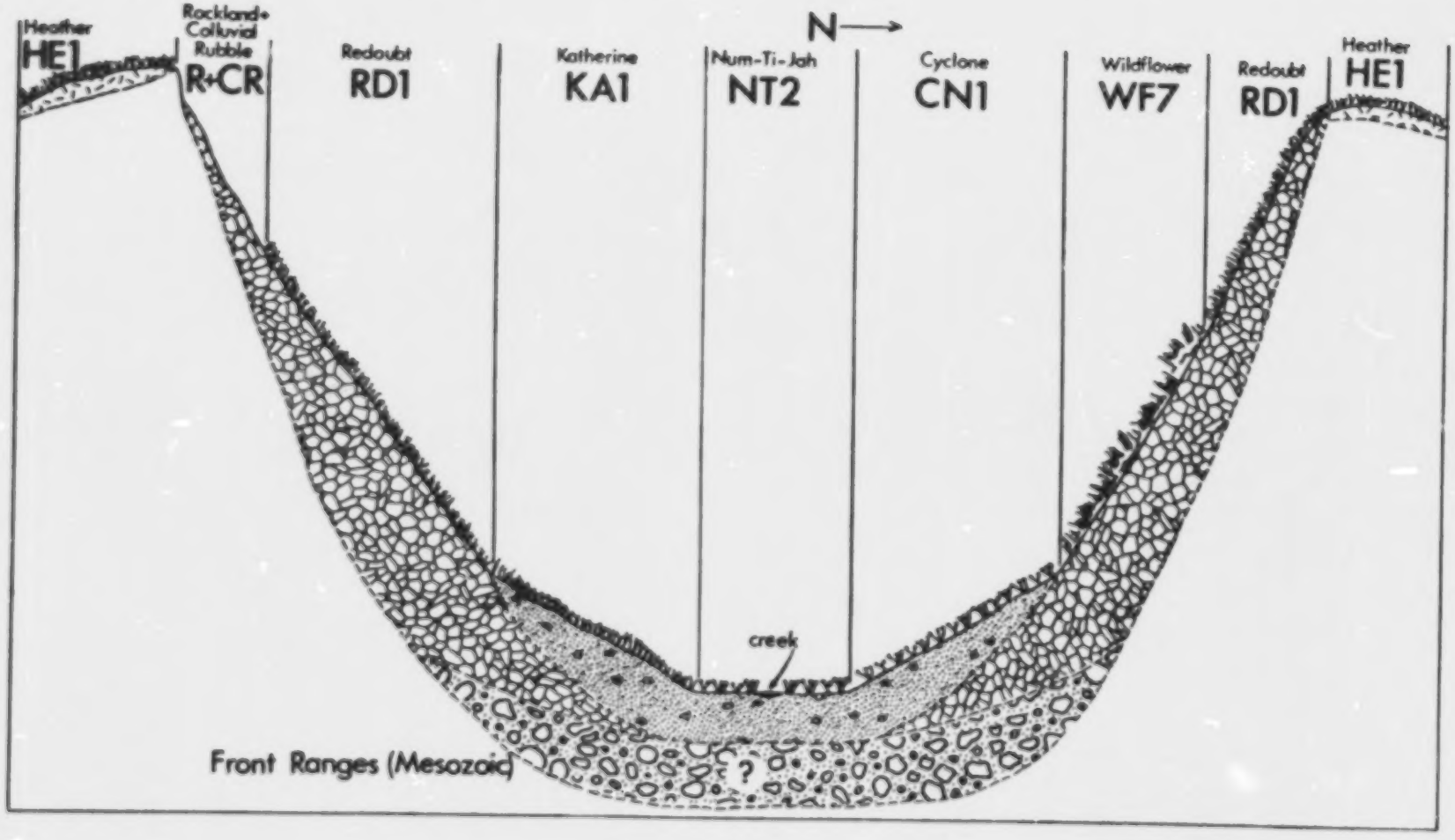
The Katherine Ecosection is complex and encompasses fluvial aprons and fans throughout the Alpine Ecoregion in Banff and Jasper. These landforms consist of noncalcareous, coarse, stratified fluvial material (Fluvial material A) and calcareous, coarse, stratified fluvial material (Fluvial material B) derived primarily from medium and fine grained clastic strata or associated geomorphic materials. Channeling (Eroded modifier, C.S.S.C. 1978b) and solifluction are common surface features.

Moist to wet conditions (moderately well, imperfectly and poorly drained classes), often with episodic seepage, and disturbance by solifluction and sediment deposition influence soil and vegetation distribution. Regosolic and Gleysolic soils under dwarf shrub-herb meadow and mountain avens tundra vegetation characterize KA. One Ecosite (KA1) is recognized; its features are summarized in Table 233. Katherine occurs most often on lower valley wall slopes and valley floors (Fig. 42). Variable seepage conditions related to snow melt and soil thaw on slopes above KA maintain its moist to wet conditions. It is most extensive in the Front Ranges in association with Mesozoic strata. Occurrences in the Main Ranges are generally related to slaty and shaly strata.

Table 233 General features of the Katherine 1 (KA1) Ecosite.

Ecosite	Landform	Soils	Vegetation
KA1	Fluvial material A,B; apron, fan	Regosolic, Gleysolic	dwarf shrub-herb meadow, mountain avens tundra

Figure 42 Landscape schematic showing the relationship of the Katherine 1 (KA1) Ecosite to other Ecosites.



KA1 KATHERINE 1 ECOSITE

Ecosite Concept

The Alpine Ecosite, KA1, encompasses moist to wet fluvial aprons and fans comprised of noncalcareous, coarse, stratified fluvial material (Fluvial material A) and calcareous, coarse, stratified fluvial material (Fluvial material B). Surfaces are usually eroded (channeled) and solifluted.

Soils and vegetation of KA1 are related to moisture regime, which reflects seasonal and episodic seepage, and to surface disturbances, mainly solifluction. Cumulic Humic Regosols, Gleyed Cumulic Humic Regosols, and Rego Gleysols dominate KA1 and range from moderately well drained to poorly drained. Vegetation is dominated by the arctic willow-cinquefoil (L7) and mountain avens-snow willow-moss campion (H1) v.t.s.

Geomorphology

The KA1 Ecosite is typified by fluvial aprons and fans consisting of noncalcareous, coarse, stratified fluvial material (Fluvial material A) and calcareous, coarse, stratified fluvial material (Fluvial material B). Veneers and layers of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) occur occasionally. Landforms characterizing KA1 consist of material eroded by fluvial and solifluction processes from morainal, colluvial, and colluvial plus rock slopes. Stratified deposits, including interbedded and mixed humus, are manifestations of episodic fluvial deposition and mixing by solifluction. Solifluction features are more active and extensive on KA1 tracts dominated by material derived from Mesozoic strata than on fluvial material derived from other sources. On several tracts, the fluvial materials are shallow and are underlain by shallow morainal deposits. Small morainal landforms occur sporadically. On gentle, poorly drained slopes, KA1 soils are occasionally thinly mantled by moderately decomposed fen peat derived from sedges and mosses.

Topographically, KA1 displays linear slopes on aprons and fans. Slopes commonly range from 1 to 30% with the gentler slopes being confined to apron and fan toes on valley floors and to minor amounts of level floodplains. Tracts with complex slopes have irregular surfaces reflecting, in part, underlying morainal landforms or rarely occurring bedrock escarpments (KA1+R). Slope continuity is often broken by abandoned and active stream channels including their natural levee margins (Eroded modifier, C.S.S.C. 1978b) and by surface manifestations of solifluction (solifluction lobes, benches and streams; Washburn 1973).

Soils

Soils of the KA1 Ecosite are complex and reflect varying drainage conditions, related to seasonal and episodic seepage, and surface disturbances, mainly solifluction. Cumulic Humic Regosols, Gleyed Cumulic Humic Regosols, and Rego Gleysols best represent KA1 soils and approximate moderately well, imperfectly, and poorly drained conditions, respectively. The Cumulic Humic Regosols and Gleyed Cumulic Humic Regosols receive varying amounts of seasonal and episodic seepage. Under the Alpine conditions, humus accumulations are common on these soils. Consequently, they have varying thicknesses of Ah horizons that, in many cases, have been physically thickened by solifluction processes. Related soils with thin or absent Ah horizons occur as accessories (Cumulic Regosols and Gleyed Cumulic Regosols). Mixing of humus and mineral materials throughout the control section is another manifestation of solifluction. Poorly drained sites that are affected by prolonged seepage and high water tables have more strongly gleyed soils (Rego Gleysols). Organo-mineral Ah horizons are thin or absent on these soils; alternately, thin peat layers have developed in many cases. Mixing of humus and mineral material is not as pronounced in the Rego Gleysols as in the other soils. Some gently sloping KA1 tracts adjacent to lakes and constricted streams are dominated by Rego Gleysols (e.g. near Devon Lakes in Banff). Humic Gleysols, Orthic Regosols, and various Brunisolic soils occur in minor amounts.

A pedon illustrating a Cumulic Humic Regosol of KA1 is described in Table 234 and shown in Color Plate 36. Its high organic carbon content and dark color are normal for genetic materials containing an abundance of carbonaceous Mesozoic shales.

Vegetation

Moisture regime, aspect, and elevation are the predominant influences on KA1 vegetation distribution. The dominant v.t.s are arctic willow-cinquefoil (L7) and mountain avens-snow willow-moss campion (H1). Near the lower elevational limits of KA1, L7 tends to be more abundant on northerly aspects that have imperfect to poor drainage. The H1 v.t. occurs more often on drier sites (moderately well to imperfectly drained) and at higher elevations than L7. Intergrades between the two types are common on KA1. Willow/cinquefoil (S8), white mountain heather-mountain avens-snow willow (L4), water sedge-beaked sedge (H11) and fleabane-valerian (H16) occur as accessory v.t.s. The S8 v.t. occurs on sites similar to those on which L7 occurs. The L4 v.t. is often associated with L7 but on drier sites. The H11 v.t. occurs on gently sloping, often ponded localities adjacent to

Table 234 Pedon (Alberta 1979 No. 90) description of a Cumulic Humic Regosol of the KA1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: CUMULIC HUMIC REGOSOL. SOIL MAP UNIT: NOTATION: KA1.

LOCATION: MILITARY GRID REF. 11 UNH 8190 1460; NTS MAP AREA 82O 12H.

CLIMATE: 2250 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 2 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: VPN=JB9081*VTN=L7*.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND STRATIFIED (MINERAL), WEAKLY CALCAREOUS (1 TO 6% CACO3), FLUVIAL AND ORGANIC, SEDIMENTARY; LANDFORM CLASSIFICATION: FLUVIAL, SOLIFLUCTED, APRON; SLOPE: 10% SIMPLE SLOPE OF CLASS 5 (10-15%), FACING NORTH AND NORTHWEST, SITE AT MIDDLE POSITION, STRONGLY MOUNDED MICROTOPOGRAPHY, 100 M LONG; SOIL MOISTURE AND DRAINAGE: MODERATELY WELL DRAINED, MODERATE SURFACE RUNOFF; MODERATELY STONY; NONROCKY.

SPECIAL NOTES: SSN=MT9149*APN=810-164*RLU=15*PCF=3AG,2AC(3)BAG(4)3AG,3AC(5)*LFH=FA-S,E*AH IS TURFY*DATE=AUG.28,1979*CK1 HORIZON HAS BEEN MIXED BY SOLIFLUCTION*

LF: 2 TO 0 CM, RANGE 2 TO 3 CM; MATRIX MOIST 10YR 3/1; SMOOTH, ABRUPT HORIZON BOUNDARY.

AH: 0 TO 14 CM, RANGE 11 TO 15 CM; MATRIX MOIST 7.5YR 3/1; COARSE SANDY LOAM; STRUCTURELESS, FINE, GRANULAR STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE ROOTS; 30% COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

C+A: 14 TO 55 CM, RANGE 25 TO 35 CM; MATRIX MOIST 2.5Y 2/1; LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, FINE ROOTS; VERY WEAK EFFERVESCENCE; 30% ANGULAR GRAVELLY AND ANGULAR COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

CK1: 55 TO 100 CM, RANGE 40 TO 50 CM; MATRIX MOIST 2.5Y 2/1; GRAVELLY COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, FINE ROOTS; WEAK EFFERVESCENCE; MODERATELY CALCAREOUS; 40% ANGULAR GRAVELLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

CK2: 100 TO 110 CM; MATRIX MOIST 2.5Y 2/1; COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, FINE ROOTS; WEAK EFFERVESCENCE; WEAKLY CALCAREOUS; 30% ANGULAR GRAVELLY AND ANGULAR COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	6.2	24.90							
AH	6.3	8.10		21.3		17.0	4.6	-.1	0.3
C+A	6.4	11.80							
CK1	7.0	5.20	0.6						
CK2	7.1	7.40	2.7						

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AH					21	23	9	5	4	64		28	8	
C+A					9	18	7	7	8	41		47	12	
CK1	99	97	78	44	11	20	13	9	8	61		31	8	
CK2	99	65	47	32	11	18	10	8	8	55		44	11	

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AH								
C+A								
CK1							12	97
CK2	20.0	24.0		10.0	1.7		11	17

lakes and constricted streams. The H16 v.t. occurs on imperfectly to poorly drained sites and is most abundant on the high snowfall areas of western to central Banff and Jasper. The black alpine sedge-everlasting (H2), cottongrass/moss (H10) and heather-everlasting (L5) v.t.s occur in minor amounts on KA1. A plot representing vegetation of the pedon sample site (Table 234) and illustrating L7 on KA1 is presented in Table 235 and Plate 133.

Table 235 Stand (JD9081) illustrating the arctic willow-cinquefoil (L7) v.t. of the KA1 Ecosite.

	HERB-DWARF SHRUB LAYER
Androsace chamaejasme	.5
Astragalus alpinus	01
Carex spp.	.5
Castilleja occidentalis	.5
Delphinium glaucum	01
Draba spp.	.5
Dryas octopetala	45
Festuca spp.	.5
Gentiana propinqua	.5
Kobresia myosuroides	.5
Poa alpina	.5
Poa spp.	01
Polygonum viviparum	01
Potentilla diversifolia	01
Salix arctica	40
Salix nivalis	01
Senecio lugens	.5
Smelowskia calycina	.5
Solidago multiradiata	05
Stellaria spp.	.5
Trisetum spicatum	.5
Equisetum scirpoides	.5
	BRYOID LAYER
Cetraria cucullata	.5
Cetraria ericetorum	01
Peltigera spp.	.5
Thuidium abietinum	.5
Tortula ruralis	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The KA1 Ecosite encompasses fluvial landscape in the Alpine Ecoregion and is of limited areal extent. It marginally resembles a few other Ecosites. Dry, more steeply sloping portions resemble the Upper Subalpine Cyclone 1 (CN1) Ecosite but can be distinguished by meadow and tundra vegetation in KA1 versus shrub vegetation in CN1. Gently sloping, wet portions of KA1 broadly resemble the Num-Ti-Jah 2 (NT2) Ecosite. However, NT2 in contrast to KA1, includes extensive level floodplain landforms and is dominated by shrubby vegetation. The steepest sloping portions of KA1 occasionally resemble the Alpine colluvial Ecosites, but can be distinguished by their fluvial parent materials.

LV - LARCH VALLEY ECOSECTION

The Larch Valley Ecosection encompasses morainal landforms comprised of noncalcareous, coarse textured till (Till A) in the Upper Subalpine portion of the Subalpine Ecoregion of Banff and Jasper. It occurs in the Main Ranges, primarily on valley walls and shoulders, cirque basins, and cols in areas that are geologically dominated by Cambrian Gog Group quartzites.

The dominant soils, Dystric Brunisols, are comparatively well developed and reflect the acidic, coarse textured parent material in that they are deeply weathered and strongly eluviated. Podzolic soils are subdominant and reflect the presence of altered, medium textured eolian material (Eolian material B). Two groups of coniferous forest and open forest, and a distinctive pattern of tundra plus coniferous open forest differentiate the three Larch Valley Ecosites (Table 236). Fig. 43 shows the Larch Valley (LV) Ecosites in relation to their Lower Subalpine (ML1, ML2) and Alpine (EF1) counterparts.

LV1 - LARCH VALLEY 1 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, LV1, occurs on morainal blankets consisting of noncalcareous, coarse textured till (Till A) overlying inclined, hummocky, or ridged bedrock. Veneers of altered, medium textured eolian material (Eolian material B) occur extensively and significantly affect soil development. Consequently, LV1 exhibits a pattern of deeply weathered soils in which Eluviated Dystric Brunisols are dominant and Orthic Humo-Ferric Podzols are subdominant. Vegetation cover is dominated by the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. The LV1 Ecosite is least extensive of the Larch Valley Ecosites and is found only in the Main Ranges south of Hector Lake in Banff.

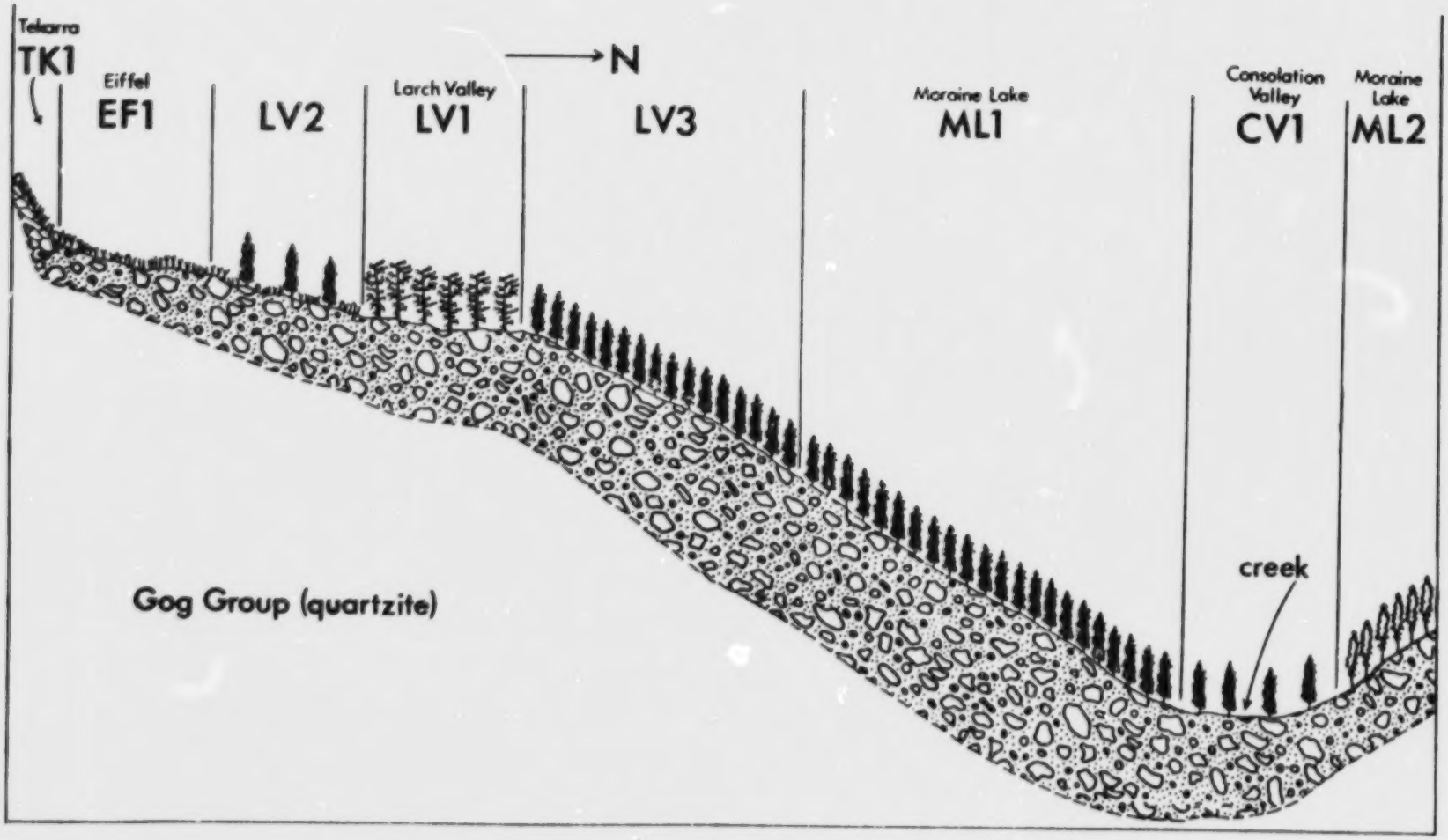
Geomorphology

The LV1 Ecosite is typified by morainal blankets overlying inclined, hummocky, or ridged bedrock. These moraines consist of noncalcareous, coarse textured till (Till A). Veneers of altered, medium textured eolian material (Eolian material B) occur extensively. Colluvium derived from till and fractured bedrock is found occasionally on the steepest portions of the landscape.

Table 236 General features of the Larch Valley (LV) Ecosites.

Ecosite	Landform	Soils	Vegetation
LV1	Till A; blanket	Dystric Brunisol > Podzolic	subalpine larch-subalpine fir forest
LV2	Till A; blanket, veneer	Dystric Brunisol > Sombric Brunisol, Podzolic	heath tundra > Engelmann spruce-subalpine fir open forest
LV3	Till A; blanket	Dystric Brunisol > Podzolic	Engelmann spruce-subalpine fir closed and open forests

Figure 43 Landscape schematic showing the relationship of the Larch Valley (LV) Ecosites to other Ecosites.



Topographically, the LV1 Ecosite displays linear slopes consisting of till mantling inclined bedrock on valley wall slopes (including spur ridges) or hummocky and ridged bedrock of shoulders, cirque basins, and cols. Slopes are normally 15 to 70%. The linear slopes are often gullied. Morainal veneers and bedrock outcrops occur occasionally. In tracts mapped as LV1X, such as the one located at the north end of Panorama Ridge in Banff, the terrain is dominated by morainal veneers and lithic soils. Additionally, bedrock outcrops occur locally along ridge crests and on the steepest portions of the landscape. Patches of colluvium frequently occur below these steep bedrock escarpments. Comparatively deep till deposits, usually with a hummocky surface form, occur occasionally on cirque floors and failed slopes.

Soils

Eluviated Dystric Brunisols are the dominant soils of the LV1 Ecosite and Orthic Humo-Ferric Podzols are the subdominant soils. These well drained soils reflect the presence of nearly continuous veneers of altered, medium textured eolian material (Eolian material B) in that they have Bf or podzolic Bf horizons above and Bm horizons below the parent material disconformity. In addition, their deep sola reflect the acidity and the highly pervious nature of the coarse textured, till genetic materials. Weak cementation (duric tendencies) in lower Bm or BC horizons may also occur. Orthic Dystric Brunisols and others lacking well develop Ae horizons occur in localities recently affected by erosional processes such as avalanching, gullying or shallow surface colluviation or where significant humus input masks the effects of eluviation. Most LV1 soils show, in their upper sola, humic enrichment often associated with the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. Consequently, soils with Bhf and podzolic Bhf horizons occur occasionally. Small amounts of wet soils associated with seeps occur in depressional portions of the landscape. Lithic soil phases are abundant only on LV1X tracts.

A pedon illustrating Eluviated Dystric Brunisols of the LV1 Ecosite is described in Table 237 and shown in Color Plate 37. It has slightly higher than normal organic carbon content in the upper solum. This combined with some surface disturbance has masked the effects of eluviation. The relatively finer texture in the fine earth fraction of the IIC horizon may be attributable to minor incorporation of Miette Group slates and shales that underlie the noncalcareous, coarse textured till at this site.

Vegetation

The LV1 Ecosite is dominated by the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. Open tree canopy variants of the C23 v.t. occur on exposed sites and along the upper elevational boundaries of LV1 tracts. Stunted variants or other avalanche v.t.s such as subalpine fir-willow (S2) occur on avalanche paths. Because of map scale limitations, many LV1 tracts have minor amounts of Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) or Engelmann spruce-subalpine fir/heather (O10) along lower elevational boundaries and patches of heather-everlasting (L5) along upper boundaries. Various moist to wet Upper Subalpine v.t.s plus the C23 v.t. are associated with seeps in depressional sites. A stand representing vegetation of the pedon sampling site described above (Table 237) and illustrating the C23 v.t. of the LV1 Ecosite is depicted in Table 238 and Plate 134.

Table 238 Stand (JE8157) illustrating the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. of the LV1 Ecosite.

TREE LAYER	
Abies lasiocarpa	07
Larix lyallii	12
Picea engelmannii	01
TALL SHRUB LAYER	
Abies lasiocarpa	04
Larix lyallii	01
Picea engelmannii	.5
SHRUB LAYER	
Abies lasiocarpa	01
Larix lyallii	.5
Picea engelmannii	.5
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	01
Anemone parviflora	.5
Antennaria lanata	01
Arnica latifolia	01
Erigeron peregrinus	.5
Juniperus communis	.5
Larix lyallii	.5
Myosotis alpestris	.5
Pedicularis bracteosa	.5
Phyllodoce glanduliflora	02
Picea engelmannii	.5
Sibbaldia procumbens	.5
Trisetum spicatum	.5
Vaccinium scoparium	50
Veronica alpina	.5
BRYOID LAYER	
Brachythecium spp.	.5
Cetraria islandica	.5
Cladonia chlorophaea	.5
Cladonia ecmocyna	.5
Cladonia squamosa	.5
Dicranum brevifolium	.5
Dicranum scoparium	.5
Drepanocladus spp.	.5
Peltigera aphthosa	.5
Polytrichum juniperinum	.5
Rhizocarpon geographicum	.5
EPIPHYTES	
Cetraria pinastri	.5
Letharia vulpina	.5
Parmelia exasperatula	.5
Parmeliopsis ambigua	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Table 237 Pedon (Alberta 1978 No. 96) description of an Eluviated Dystric Brunisol of the LV1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: MSTATION: LV1.

LOCATION: MILITARY GRID REF. 11 UNB 5940 6700; NTS MAP AREA 82N 6E.

CLIMATE: 2350 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 1 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VPN=JE8157#VTH=C23#.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN; PARENT MATERIAL 2: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), MORAINAL (TILL), QUARTZITE; LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 47% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING WEST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,400 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, RAPIDLY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; VERY STONY; NONROCKY.

SPECIAL NOTES: SSN=BNB1436APH=703-62#RLU=18#SSC#ST#PCF=1CB,1ST(1-3)4GR,2CB,1ST(4-5)BGR,3CB,3ST(6-7)#AHE HORIZON IS DISTURBED BY FIRE,AVALANCHING,OR MASS WASTING;INCLUDES SOME B MATERIAL#LFH=MB/RI#

LFH: 2 TO 0 CM, RANGE 1 TO 3 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/1; ABUNDANT, VERY FINE AND FINE AND MEDIUM ROOTS; 10% COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

AHE: 0 TO 7 CM, RANGE 6 TO 10 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/3.5, MATRIX MOIST 10YR 3/4; SILT LOAM; VERY WEAK, FINE TO MEDIUM, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE AND MEDIUM ROOTS; 10% COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BHF: 7 TO 11 CM, RANGE 0 TO 7 CM; HORIZON MOIST; MATRIX MOIST 5YR 4/6, MATRIX MOIST 5YR 4/4; SILT LOAM; VERY WEAK, FINE TO MEDIUM, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE AND MEDIUM ROOTS; 10% COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; BROKEN, ABRUPT HORIZON BOUNDARY.

2BM: 11 TO 16 CM, RANGE 0 TO 10 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6; LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE ROOTS; 40% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; BROKEN, ABRUPT HORIZON BOUNDARY.

2BC1: 16 TO 41 CM, RANGE 19 TO 40 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/3.5; LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; FEW, MICRO AND VERY FINE ROOTS; 40% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2BC2: 41 TO 61 CM, RANGE 18 TO 26 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/6; SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; VERY FEW, MICRO AND VERY FINE ROOTS; 70% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2C: 61 TO 110 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/4, MATRIX MOIST 10YR 4/4; SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, MICRO AND VERY FINE ROOTS; 70% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LFH	4.7	32.70						
AHE	4.4	3.70	21.6		1.3	0.4	0.1	0.2
BHF	4.8	5.90	35.3		1.3	0.4	0.1	0.1
2BM	4.8	1.30	6.3		0.7	0.2	-.1	-.1
2BC1	4.4		2.6		0.2	0.1	0.0	-.1
2BC2	4.8		2.2		0.4	0.1	-.1	-.1
2C	4.4		2.2		0.3	0.1	-.1	-.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LFH				
AHE				
BHF	0.5		0.7	
2BM	0.1		0.1	
2BC1				
2BC2				
2C				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LFH														
AHE					1	1	1	14	10	27		65	8	
BHF					1	1	2	4	10	18		75	7	
2BM					9	12	20	30	8	79		18	3	
2BC1					8	9	17	36	12	81		17	2	
2BC2					10	11	16	37	12	86		12	0	
2C	99	71	52	44	7	10	11	21	12	61		34	5	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LFH													
AHE		44.4	19.1										
BHF													
2BM		10.3	5.2										
2BC1													
2BC2		4.4	1.3										
2C		11.1	1.8									12	07

Discussion

The LV1 Ecosite is the least extensive of the Larch Valley Ecosites. Its distribution is governed by the narrow elevational (2200-2400 m) and geographic range of the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. on noncalcareous, coarse textured till (Till A). In terms of physiographic position, landform surface expression, and vegetation, LV1 resembles the Egypt 2 (EG2) and Peyto Lake 3 (PL3) Ecosites. However, EG2 is distinguished because it occurs on morainal landforms consisting of noncalcareous, medium textured till (Till B), whereas PL3 is distinguished because it occurs on calcareous, medium textured till (Till C). Also, PL3 is dominated by Eutric Brunisols with relatively thin sola. The EG2 Ecosite exhibits similar but thinner soil development compared to LV1 soils. The LV2 and LV3 Ecosites are primarily differentiated by vegetation as outlined in Table 236.

LV2 - LARCH VALLEY 2 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, LV2, occurs on morainal blankets and veneers consisting of noncalcareous, coarse textured till (Till A) overlying inclined, hummocky, and ridged bedrock. The dominant soils are deeply weathered Eluviated Dystric Brunisols. Orthic Dystric Brunisols, Orthic Sombric Brunisols, and Orthic Ferro-Humic Podzols are subdominant and reflect high humus input from the vegetation and, in some localities, the presence of altered, medium textured eolian material (Eolian material B). A distinct pattern comprised of the heather-everlasting (L5) v.t. interspersed with islands of the Engelmann spruce-subalpine fir/heather (O10) v.t. characterizes the vegetation component of this Ecosite.

The LV2 Ecosite represents the uppermost part of the Upper Subalpine on noncalcareous, coarse textured till and is normally bounded above by Alpine Ecosites and below by Upper Subalpine Ecosites with closed to open forests of Engelmann spruce-subalpine fir or subalpine larch-subalpine fir.

Geomorphology

The LV2 Ecosite is typified by morainal blankets and veneers overlying inclined, hummocky, or ridged bedrock. These moraines consist of Till A. Veneers of altered, medium textured eolian material occur extensively on LV2 tracts located in Western Banff and southwestern Jasper and sporadically on tracts of other areas. Colluvium derived from till and/or fractured bedrock is found occasionally on steepest portions of the landscape.

Topographically, the LV2 Ecosite displays linear slopes consisting of till mantling inclined bedrock on upper valley slopes (including spurs) or hummocky and ridged bedrock on valley shoulders, cirque basins, and cols. Slopes of 5 to 70% are common. Morainal veneers dominate on LV2X tracts. Bedrock outcrops are most common on tracts mapped as LV2X and LV2+R. Patches of colluvium existing as blankets and veneers occur occasionally on the steepest terrain. Slopes dissected by gullies occur occasionally. Comparatively deep till deposits, usually with a hummocky surface form, occur occasionally on cirque floors and on failed slopes.

Soils

Eluviated Dystric Brunisols are the dominant soils of the LV2 Ecosite. Orthic Dystric Brunisols, Orthic Sombric Brunisols, and Orthic Ferro-Humic Podzols are subdominant. These well drained soils have deep sola that reflect the acidity and the highly pervious nature of the coarse textured, till genetic material. Weak cementation (duric tendencies) in the lower Bm or BC horizons may also occur. The vegetational characteristics of the heather-everlasting (L5) v.t. appear to result in organic matter additions to the surfaces of these soils that are significantly greater than on other Larch Valley Ecosite soils. Thus, the effects of eluviation are often masked by dark colored organic matter, particularly where altered, medium textured eolian material (Eolian material B) is present, resulting in LV2 soils that have varying thicknesses of Ah and/or Ahe horizons. In addition, where veneers of altered, medium textured eolian material are present, these soils often have Bhf or podzolic Bhf horizons above and Bm horizons below the parent material disconformity. Soils with Bf and podzolic Bf horizons occur occasionally. Lithic soil phases associated with the morainal veneers are relatively common, particularly in tracts of LV2X where they dominate. Localities with turbic soil phases produced by solifluction and cryoturbation occur occasionally but are less abundant than in the Peyto Lake 4 (PL4) and Egypt 2 (EG2) Ecosites found in similar situations but on different genetic materials. Depressional localities with seepage affected, wet soils may constitute up to 15% of LV2 tracts.

A pedon illustrating Eluviated Dystric Brunisols of the LV2 Ecosite is described in Table 239 and shown in Color Plate 38. Solifluction on this site has modified the upper solum as manifested by a relatively high clay content in the Ah horizon and mixing of eolian and till material in the Bm horizon thus diluting its iron and aluminum content.

Vegetation

The LV2 Ecosite is dominated by a vegeta-

Table 239 Pedon (Alberta 1979 No. 45) description of an Eluviated Dystric Brunisol of the LV2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: LV2.

LOCATION: MILITARY GRID REF. 11 UMJ 3715 8750; NTS MAP AREA 83C 13#.

CLIMATE: 2120 METER) ABOVE MEAN SEA LEVEL.

VEGETATION: VPN=PA9125#VTN=010#.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN, SEDIMENTARY; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND SANDY, EXTREMELY TO STRONGLY ACIDIC (PH.5.5), MORAINAL (TILL); LANDFORM CLASSIFICATION: MORAINAL, SOLIFLUCTED, BLANKET; SLOPE: 40% SIMPLE SLOPE OF CLASS 7 (31-45%), FACING NORTHEAST, SITE AT UPPER SLOPE POSITION, STRONGLY MOUNDED MICROTOPOGRAPHY,500 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; VERY STONY; HUMMOCKY.

SPECIAL NOTES: SSN=6C9066#APH=01S-111#PCF=1BR(1-2)1BR,1CB(3)3GR,1CB(4-7)#*#MB/RI=DATE=SEPT.7,1979#

AH: 0 TO 4 CM, RANGE 2 TO 6 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/4; LOAM; WEAK, MEDIUM, GRANULAR STRUCTURE; FRIABLE CONSISTENCE; ABUNDANT, FINE ROOTS; HIGHLY POROUS; WAVY, CLEAR HORIZON BOUNDARY.

AE: 4 TO 7 CM, RANGE 1 TO 6 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/2, MATRIX MOIST 10YR 4/3; SILT LOAM; MODERATE, COARSE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE ROOTS; HIGHLY POROUS, FEW, FINE PORES; WAVY, ABRUPT HORIZON BOUNDARY.

BM: 7 TO 20 CM, RANGE 5 TO 13 CM; HORIZON MOIST; MATRIX MOIST 5YR 4/6, MATRIX MOIST 5YR 4/4; LOAM AND SANDY LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; MODERATE, FINE, SUBANGULAR BLOCKY SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE ROOTS; HIGHLY POROUS, FEW, VERY FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

2BM: 20 TO 49 CM, RANGE 25 TO 35 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6; SANDY LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; MODERATELY POROUS, FEW, FINE PORES; WAVY, GRADUAL HORIZON BOUNDARY.

2BC1: 49 TO 90 CM, RANGE 34 TO 45 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/4; COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; MODERATELY POROUS, FEW, FINE PORES; WAVY, DIFFUSE HORIZON BOUNDARY.

2BC2: 90 TO 120 CM, RANGE 20 TO 40 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6; COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; MODERATELY POROUS, FEW, VERY FINE PORES; WAVY, DIFFUSE HORIZON BOUNDARY.

2C: 120 TO 135 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6; SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; MODERATELY POROUS, FEW, FINE PORES.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
AH	4.5	13.90	49.0		12.4	2.4	0.1	1.3
AE	4.5	4.50	17.1		1.9	0.3	0.1	0.2
BM	4.6	2.20	15.1		2.1	0.5	0.1	0.1
2BM	5.1	0.50	4.7		1.3	0.3	-.1	0.1
2BC1	5.7		2.3		1.2	0.1	-.1	0.1
2BC2	6.2		2.6		1.7	0.3	-.1	0.1
2C	5.3		2.7		1.3	0.2	-.1	0.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
AH				
AE				
BM	0.4		0.1	
2BM	0.1		-.1	
2BC1				
2BC2				
2C				

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
AH					2	2	3	7	7	25		49	26		
AE					4	7	7	8	9	35		52	13		
BM					11	13	11	10	7	52		33	15		1.20
2BM					9	13	16	16	10	64		27	9		
2BC1					11	15	19	15	5	65		30	5		
2BC2					13	10	14	13	8	66		29	5		2.00
2C	99	93	80	73	8	14	17	17	9	67		29	4		1.90

PHYSICAL DATA

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AH								
AE								
BM								
2BM								
2BC1								
2BC2								
2C							24	87

tion pattern in which the heather-everlasting (L5) v.t. is more abundant than the Engelmann spruce-subalpine fir/heather (O10) v.t. The O10 v.t. normally exists as discrete patches or islands of trees but includes islands of krummholz on exposed sites or at the Upper Subalpine-Alpine boundary. Within the elevational range of LV2, tree islands cover about 50% of the landscape at lowest elevations, 5% at highest elevations. Islands of the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. often replace O10 on LV2 tracts located in southwestern Banff. Patches of the white mountain heather-mountain avens-snow willow (L4) v.t. and the mountain avens-snow willow-moss campion (H1) v.t. occur occasionally, with H1 being restricted to exposed ridge and hummock crests. Seepage affected depressional localities often have moist to wet Upper Subalpine v.t.s such as fleabane-valerian (H16) or cottongrass/moss (H10). Modification by avalanching and fire, although difficult to identify on LV2 vegetation, occurs occasionally. A stand representing vegetation of the pedon sample site described above (Table 239) and illustrating the O10 v.t. segment of the LV2 vegetation pattern is depicted in Table 240 and Plate 135.

Table 240 Stand (PA9125) illustrating the Engelmann spruce-subalpine fir/heather (010) portion of the v.t. pattern of the LV2 Ecosite.

TREE LAYER	
Abies lasiocarpa	05
TALL SHRUB LAYER	
Abies lasiocarpa	.5
Picea engelmannii	.5
SHRUB LAYER	
Abies lasiocarpa	.5
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	.5
Antennaria lanata	.5
Artemisia norvegica	05
Cassiope tetragona	10
Dryas octopetala	.5
Pedicularis bracteosa	.5
Phyllodoce glanduliflora	55
Poa alpina	.5
Salix arctica	05
Vaccinium scoparium	05
Lycopodium alpinum	.5
BRYOID LAYER	
Barbilophozia hatcheri	05
Cetraria hepatizon	.5
Cetraria islandica	05
Cladonia coccifera	.5
Cladonia ecmocyna	02
Cladonia gracilis	01
Cladonia mitis	10
Cladonia uncialis	02
Dicranum scoparium	25
Grimmia alpestris	.5
Grimmia apocarpa	.5
Lepraria neglecta	.5
Lobaria linita	.5
Lophozia spp.	02
Pannaria pezizoides	.5
Pohlia spp.	03
Rhizocarpon geographicum	.5
Umbilicaria hyperborea	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

The LV2 Ecosite represents the Upper Subalpine-Alpine ecotone on noncalcareous, coarse textured till (Till A). In terms of physiographic position, landform surface expression, and vegetation, LV2 resembles the Egypt 4 (EG4) and Peyto Lake 4 (PL4) Ecosites. However, EG4 can be distinguished because it occurs on morainal landforms consisting of noncalcareous, medium textured till (Till B) and PL4 can be distinguished because it occurs on calcareous, medium textured till (Till C). Also EG4 exhibits taxonomically similar but thinner soil development than LV2 and PL4 is dominated by Eutric and Melanic rather than Dystric and Sombric Brunisols. The LV1 and LV3 Ecosites are primarily differentiated by vegetation as outlined in Table 236.

LV3 - LARCH VALLEY 3 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, LV3, occurs on morainal blankets consisting of noncalcareous, coarse textured till (Till A) overlying inclined bedrock on valley walls. The dominant soils are deeply weathered, strongly leached Eluviated Dystric Brunisols. Orthic Humo-Ferric Podzols are subdominant and are associated with veneers of altered, medium textured eolian material (Eolian material B). Vegetation cover is dominated by the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21), and Engelmann spruce-subalpine fir/heather (O10) v.t.s.

Geomorphology

The LV3 Ecosite is typified by morainal blankets overlying inclined bedrock on valley walls. These moraines consist of noncalcareous, coarse textured till (Till A). The LV3 Ecosite is associated with Cambrian Gog Group quartzites except for a few tracts. A tract mapped as LV3FA near Pipestone Pass warden cabin in Banff contains till derived from the Mount Wilson Formation. Source rocks for the LV3 tracts at Palliser Pass in Banff are inferred to be quartz sandstone layers of the Rocky Mountain Group. Surface veneers of altered, medium textured eolian material (Eolian material B) are extensively distributed over LV3 tracts of western Banff and southwestern Jasper and sporadically distributed in northern Jasper. Colluvium

derived from till and/or fractured bedrock is found occasionally on the steepest portions of the landscape. Noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A) occurs rarely.

Topographically, the LV3 Ecosite displays long linear slopes consisting of till mantling the inclined bedrock that forms valley walls. Slopes are normally 15 to 70% and are often dissected by parallel gullies oriented perpendicular to the contour. Small fluvial fans and aprons emanating from gully mouths along the valley bottom or other major slope breaks may be included in LV3 tracts. Patches of colluvium existing as blankets and veneers occur occasionally on the steepest terrain. Tracts mapped as LV3 situated along valley bottoms, at valley confluences, on valley shoulders, in cirque basins, and on failed slopes often display morainal landforms with irregular surfaces and complex topography (5-45% slopes). These landforms include morainal blankets and veneers overlying ridged and hummocky bedrock and the relatively deep till of hummocky moraines. Morainal veneers dominate in LV3X tracts. Bedrock outcrops are more common on the irregular terrain than on linear slopes and are especially common on LV3+R tracts.

Soils

The dominant soils of LV3 are well drained Eluviated Dystric Brunisols with comparatively thick sola and thick, well developed, eluvial (Ae) horizons that reflect the acidity and rapidly pervious coarse textures of the parent material. Where altered, medium textured eolian material is present, these Eluviated Dystric Brunisols usually have Bf horizons above and Bm horizons below the parent material disconformity and also somewhat thinner Ae horizons. Intimately associated in this geomorphic setting are the subdominant soils, Orthic Humo-Ferric Podzols, that have podzolic Bf horizons above the parent material disconformity. Soils with Bhf and podzolic Bhf horizons also occur occasionally. Weak cementation (duric tendencies) in lower Bm or BC horizons below the parent material disconformity occurs often in LV3 soils. Orthic Dystric Brunisols occur in localities recently affected by erosional processes such as avalanching, gullying, or shallow surface colluviation. Some gullies and depressional localities contain seeps and associated wet soils. Lithic soil phases are not common except on tracts mapped as LV3X where they dominate.

A pedon illustrating Eluviated Dystric Brunisols of the LV3 Ecosite is described in Table 241 and shown in Color Plate 39. Plate 34 shows the sampling site. Texture in the C horizon is coarser than modal for LV3 soils. Coarse fragments are dominantly angular because of the relatively short distance between the till's source area and the sample site.

Vegetation

The LV3 Ecosite is dominated by the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21), and Engelmann spruce-subalpine fir/heather (O10) v.t.s. The C15 v.t. is most abundant at low elevations above the boundary between the Lower and Upper Subalpine, and on southerly aspects. The C21 replaces C15 throughout northern Jasper (north of the range of *Vaccinium scoparium*) and on many LV3 tracts near the Continental Divide. The O10 v.t. occurs at higher elevations than C15 or C21 and is most extensive on northerly aspects. The accessory v.t., Engelmann spruce-subalpine fir/heather/feathermoss (C34), often occurs at higher elevations than C15 or C21 and below O10. Various moist to wet Upper Subalpine v.t.s are associated with seeps found in some gullies and depressional sites. Avalanche v.t.s such as subalpine fir-willow (S2) occur on avalanched tracts (LV3A). Fire affected vegetation in which spruce is regenerating occurs in some areas.

A stand illustrating the C15 v.t. of the LV3 Ecosite is described in Table 242. This stand is located a short distance up valley from the pedon sample site described above (Table 241). It has a low cover of *Vaccinium scoparium* compared to the central concept of the C15 v.t.

Discussion

The LV3 Ecosite is the most extensive of the Larch Valley Ecosites. In terms of physiographic position, landform surface expression, and vegetation, LV3 resembles the Egypt 1 (EG1) and Peyto Lake 1 (PL1) Ecosites. However, EG1 occurs on morainal landforms consisting of noncalcareous, medium textured till (Till B) and PL1 occurs on calcareous, medium textured till (Till C) which distinguishes it from LV3. Also EG1 exhibits taxonomically similar but thinner soil development compared to LV3 and PL1 is dominated by Eutric rather than the Dystric Brunisols of LV3. The LV1 and LV2 Ecosites are primarily differentiated from LV3 by vegetation as outlined in Table 236.

MC - MERLIN CASTLE ECOSECTION

The Merlin Castle (MC) Ecosection is characterized by veneers and blankets of calcareous, fine textured glaciolacustrine material overlying ridged, hummocky, and undulating slopes of calcareous glacial materials. Its complex topography forms a wet and dry landscape pattern. Wet depressional areas comprise about 80% of the landscape and are dominated by Gleysolic and gleyed Brunisolic soils and wet spruce open forest and birch fen. The dry portions of the landscape are

Table 241 Pedon (Alberta 1979 No. 52) description of an Eluviated Dystric Brunisol of the LV3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: LV3.

LOCATION: MILITARY GRID REF. 11 UMJ 2530 3565; NTS MAP AREA 830 9*.

CLIMATE: 1900 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 6 DEG(C) AT 13 CM IN AUGUST, NO. 2 WAS 6 DEG(C) AT 52 CM IN AUGUST, NO. 3 WAS 5 DEG(C) AT 135 CM IN AUGUST.

VEGETATION: VPN=PA9113*VTN=C34*.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND SANDY, MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), MORAINAL (TILL), METAMORPHIC AND QUARTZITE; LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 35% SIMPLE SLOPE OF CLASS 7 (31-45%), FACING WEST, SITE AT LOWER SLOPE POSITION, MODERATELY MOUNDED MICROTOPOGRAPHY,500 M LONG; SOIL MOISTURE AND DRAINAGE: HUMID, RAPIDLY DRAINED, RAPIDLY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT, SLIGHT WATER EROSION; SLIGHTLY STONY; NONROCKY; HUMUS-FORM: FIBRIMOR.

SPECIAL NOTES: SSM=PS9161*APM=01B-025*PCF=4AGR,1ACB,1ST(3-4)4AGR,2ACB(5)3AGR,3ACB(6)*LFH=MB/RI*HORIZON 5 IS NOT AS RED BUT COARSER WITH MORE CEMENTATION THAN HORIZON 4*DATE=AUG.22,1979*

LF: 7 TO 0 CM, RANGE 6 TO 9 CM; HORIZON MOIST; MATERIAL COMPOSITION 90% FEATHERMOSS, SLIGHT DECOMPOSITION; <10% BY VOLUME; ABUNDANT, FINE, HORIZONTAL ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 18 CM, RANGE 16 TO 21 CM; HORIZON MOIST; CRUSHED MOIST 10YR 6/3; GRAVELLY SANDY LOAM; WEAK TO MODERATE, MEDIUM, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE AND MEDIUM, OBLIQUE, INPED ROOTS; 30% ANGULAR GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BM1: 18 TO 33 CM, RANGE 10 TO 22 CM; HORIZON MOIST; CRUSHED MOIST 7.5YR 5/6; GRAVELLY LOAMY SAND; WEAK TO MODERATE, MEDIUM TO COARSE, GRANULAR STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE AND FINE, OBLIQUE, INPED ROOTS; 40% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY; VERY STRONGLY ACID 4.6-5.0 FIELD PH.

BM2: 33 TO 68 CM, RANGE 32 TO 41 CM; HORIZON MOIST; CRUSHED MOIST 7.5YR 4/6, CRUSHED MOIST 5YR 5/6; GRAVELLY LOAMY SAND; WEAK, MEDIUM TO COARSE, GRANULAR STRUCTURE; FIRM CONSISTENCE; WEAKLY CEMENTEDBY IRON, CONTINUOUS; 40% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

BC: 68 TO 113 CM, RANGE 35 TO 50 CM; HORIZON MOIST; CRUSHED MOIST 10YR 5/6; GRAVELLY LOAMY SAND; STRUCTURELESS, MASSIVE STRUCTURE; VERY FIRM CONSISTENCE; WEAKLY CEMENTEDBY IRON, CONTINUOUS; 40% ANGULAR GRAVELLY AND ANGULAR COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

C: 113 TO 145 CM; HORIZON MOIST; CRUSHED MOIST 10YR 5/4; COARSE SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; 30% COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	3.5	35.10						
AE	4.4	1.10	6.5		0.5	0.3	-.1	0.1
BM1	4.7	0.40	4.2		0.5	0.2	0.0	-.1
BM2	4.4	0.80	4.5		0.1	0.0	-.1	-.1
BC	5.3		1.6		0.2	0.1	0.0	-.1
C	5.9		0.8		0.3	0.1	0.0	-.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM1	0.1		-.1	
BM2	0.2		-.1	
BC				
C				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF					9	11	14	16	8	58		39	3		0.70
AE					8	13	20	24	9	74		25	1		1.60
BM1					6	12	23	27	9	77		20	3		1.70
BM2					8	15	23	25	10	81		19	0		2.00
BC															
C	99	88	67	58	10	22	31	23	5	91		9	0		

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AE								
BM1								
BM2								
BC							12	06
C								

Table 242 Stand (JC7080) illustrating the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. of the LV3 Ecosite.

TREE LAYER	
Abies lasiocarpa	19
Picea engelmannii	21
TALL SHRUB LAYER	
Abies lasiocarpa	08
SHRUB LAYER	
Abies lasiocarpa	09
Juniperus communis	01
HERB-DWARF SHRUB LAYER	
Aquilegia flavescens	.5
Artemisia norvegica	02
Deschampsia atropurpurea	01
Empetrum nigrum	01
Erigeron peregrinus	.5
Pedicularis bracteosa	.5
Phyllodoce empetriformis	01
Phyllodoce glanduliflora	01
Pyrola secunda	.5
Vaccinium myrtillus	02
Vaccinium scoparium	15
BRYOID LAYER	
Barbilophozia lycopodioides	30
Cetraria islandica	.5
Cladonia arbuscula	.5
Cladonia carneola	.5
Cladonia cornuta	01
Cladonia ecmocyna	01
Cladonia gonecha	01
Cladonia phyllophora	.5
Dicranum brevifolium	.5
Dicranum scoparium	09
Lepreria spp.	01
Lophozia spp.	.5
Peltigera aphthosa	.5
Pleurozium schreberi	01
Pohlia nutans	.5
Polytrichum juniperinum	.5
Stereocaulon spp.	.5
EPIPHYTES	
Alectoria sarmentosa	.5
Bryoria glabra	.5
Cetraria pinastri	.5
Hypogymnia austerodes	.5
Hypogymnia enteromorpha	.5
Hypogymnia physodes	.5
Letharia vulpina	.5
Parmelia exasperatula	.5
Parmelia sulcata	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

dominated by Luvisolic and Brunisolic soils and lodgepole pine and Engelmann spruce—subalpine fir forests.

The MC Ecosection occurs in the Lower Subalpine portion of the Subalpine Ecoregion in both both Banff and Jasper. It occupies valley floor benchland positions in the lower Rocky and upper Miette River valleys in Jasper and the Pipestone and Mistaya River and Johnston Creek valleys in Banff.

The MC Ecosection is represented by only one Ecosite (MC1). The general features of this Ecosite are outlined in Table 243. Fig. 44 shows the position of MC1 on the landscape.

MC1 - MERLIN CASTLE 1 ECOSITE

Ecosite Concept

The Merlin Castle 1 (MC1) Ecosite represents a wet and dry landscape pattern characterized by veneers and blankets of calcareous, fine textured glaciolacustrine material overlying ridged, hummocky, and undulating slopes of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). The wetland portion of MC1 dominates about 80% of the landscape and is typified by poorly drained Orthic and Rego Gleysols and Gleyed Eutric Brunisols associated with the spruce/Labrador tea/brown moss (O11) and dwarf birch-shrubby cinquefoil/needlerush (S3) v.t.s. The dry portion of MC1 is typified by Orthic and Brunisolic Gray Luvisols and Eluviated Eutric Brunisols associated with the lodgepole pine/Labrador tea (C29) and Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) v.t.s.

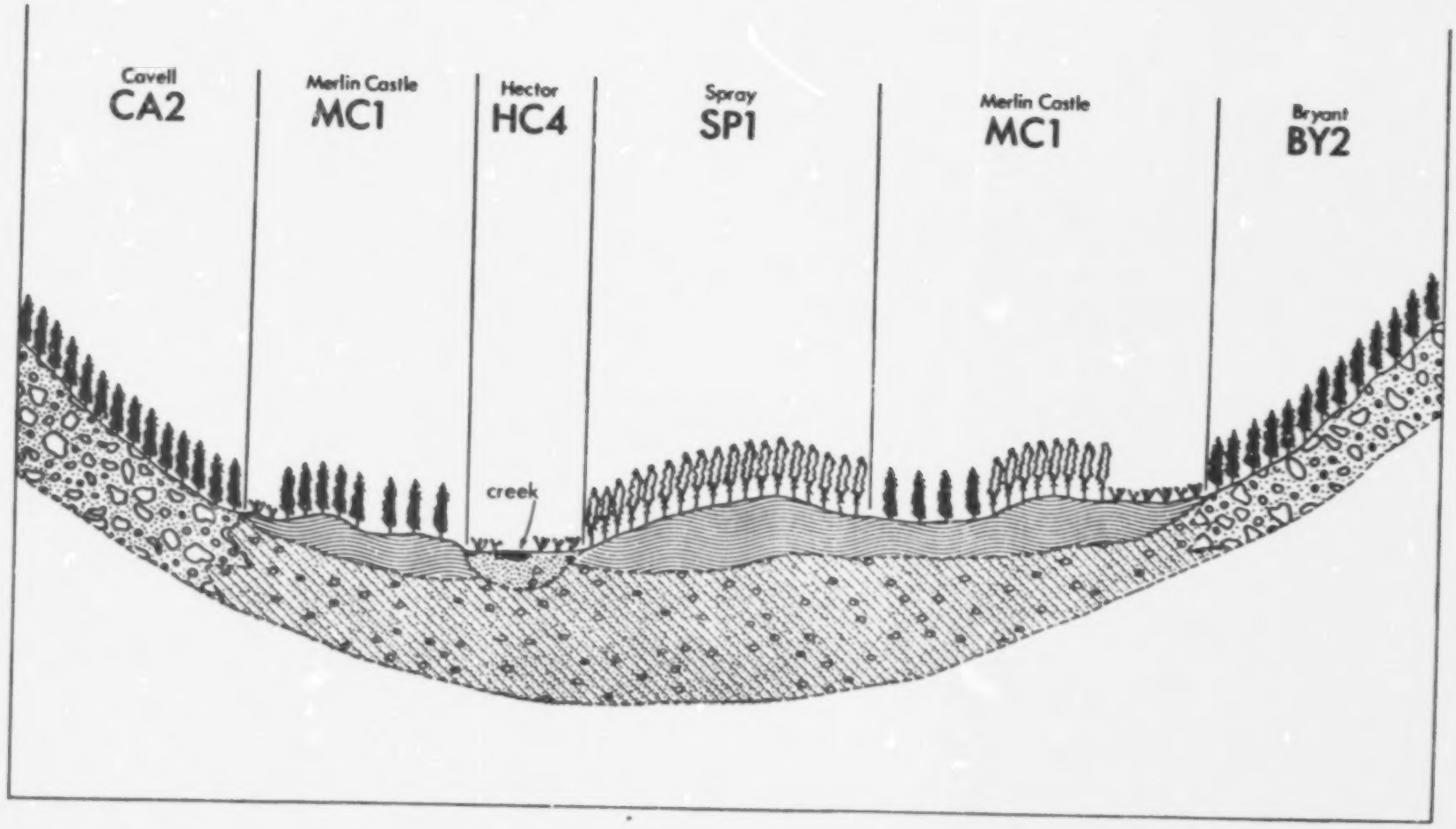
Geomorphology

The MC1 Ecosite displays a compound wet and dry landscape characterized by veneers and blankets of calcareous, fine textured glaciolacustrine material overlying ridged, hummocky, and undulating slopes of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). Minor amounts of calcareous, fine textured glaciolacustrine material overlying noncalcareous, coarse textured ice contact stratified drift (Ice

Table 243 General features of the Merlin Castle 1 (MC1) Ecosite.

Ecosite	Landform	Soils	Vegetation
MC1	Glaciolacustrine material; veneer, blanket	Wet[20]: Gleysolic, gleyed Brunisolic	Wet[20]: spruce open forest, birch fen
		Dry[20]: Luvisolic, Brunisolic	Dry[20]: lodgepole pine forest, Engelmann spruce-subalpine fir forest

Figure 44 Landscape schematic showing the relationship of the Merlin Castle 1 (MC1) Ecosite to other Ecosites.



Contact Stratified Drift A) occur in the upper Miette River valley in Jasper. In some tracts calcareous, medium textured till (Till C) is the underlying genetic material. Terraces consisting of calcareous, fine textured glaciolacustrine material overlying calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) occur locally on some tracts. The dominantly wet depressional areas on MC1 usually have thin organic veneers of fen peat and veneers of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A). Seepage and other surface waters accumulate on the landscape. Slow perviousness of the glaciolacustrine material and slow runoff on the gentle slopes result in poorly drained soils and high, possibly perched, water tables. Surficial veneers of altered, medium textured eolian material (Eolian material B) occur on the dry segments. Topographically, the MC1 Ecosite is dominated by wet depressions with occasional raised ridges breaking up the continuity of the wetland. Slopes are complex, commonly ranging from 0 to 10%. Tracts of MC1 with steeper, often linear inclined slopes occur occasionally.

Soils

Soils of the MC1 Ecosite are distributed in a pattern governed by drainage conditions. A set of pedogenically related soils occurs on the poorly drained segment. They are best represented by Orthic and Rego Gleysols, and Gleyed Eutric Brunisols. Strength of gleying, reflecting degree of saturation, is variable. Long periods of saturation inhibit pedogenic horizonation (Rego Gleysols). Orthic Gleysols and Gleyed Eutric Brunisols reflect shorter periods of saturation. The presence of eolian and fluviolacustrine veneers containing primary minerals promotes the development of iron, aluminum, and humus-enriched B and podzolic B horizons. Gleyed Podzolic soils occur in minor amounts. Many of these soils have thin organic veneers, usually of moderately decomposed fen peat. The accessory soils, Terric Mesisols, occur where the fen peat is >40 cm thick, usually under very poorly drained conditions (ponding). Other Organic soils with subdominant humic and fibric layers, gleyed Regosolic soils and Humic Gleysols occur occasionally. A pedon illustrating a Gleyed Eutric Brunisol of the wet portion of MC1 is described in Table 244 and shown in Color Plate 40. Plate 136 shows the sample site. By their textural characteristics, the Ahgj and Bfjgj horizons are developed in altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A). Because of its high clay content the Bfjgj horizon meets all but the iron plus aluminum to clay ratio specified for Bf horizons (C.S.S.C. 1978b), a feature common to MC1 soils with these veneers. This pedon was sampled in the Mistaya River valley between Chephren and Waterfowl Lakes in Banff.

The dry portion of MC1 is dominated by well to moderately well drained Orthic and Brunisolic Gray Luvisols, and Eluviated Eutric Brunisols. These soils have a clay increase giving textural B horizons, many with clay films evident in hand specimens (Bt horizons), occurring at or near the glaciolacustrine surface. Iron, aluminum, and humus enriched Bm horizons develop in veneers of altered, medium textured eolian material (Eolian material B), where present, and overlie the textural B horizons. The pedon description in Table 337 for the Spray 1 (SP1) Ecosite illustrates Orthic Gray Luvisols on the dry portions of the MC1 Ecosite.

Vegetation

Vegetation on MC1 is distributed in a pattern governed by drainage conditions. The wet portion of MC1 is dominated by the spruce/Labrador tea/brown moss (O11) and dwarf birch-shrubby cinquefoil/needlerush (S3) v.t.s on poorly drained sites. The accessory v.t., dwarf birch-shrubby cinquefoil-willow/brown moss (S1), occurs on similarly drained sites. The water sedge-beaked sedge (H11) and black spruce-lodgepole pine/willow/sedge (C8) v.t.s occur in minor amounts. A stand illustrating the O11 v.t. on the wet landscape of MC1 is described in Table 245.

A variety of lodgepole pine and Engelmann spruce-subalpine fir v.t.s, best represented by lodgepole pine/Labrador tea (C29) and Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30), occur on the dry portion of MC1. The lodgepole pine/buffaloberry/grouseberry (C18) is an accessory v.t. occurring on tracts of MC1 in the Pipestone and Mistaya River valleys in Banff. Small amounts of the Engelmann spruce-subalpine fir/heather (O10) v.t. occur on a tract of MC1 in the upper Miette River valley in Jasper. The Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t. occurs in minor amounts on tracts in the Pipestone River valley in Banff. Lodgepole pine is common on tracts mapped as MC1B in the Pipestone River valley. A vegetation plot description of a C29 v.t. in Table 338 for the Spray 1 (SP1) Ecosite also illustrates the C29 v.t. on the dry landscape of MC1.

Discussion

The characteristics of the dry landscape of MC1 are identical to those of the Spray 1 (SP1) Ecosite and the two often occur adjacent on the landscape. Where SP1 tracts occur as dry islands in a wet landscape and are too small to delineate they are considered part of the MC1 concept. The MC1 Ecosite most resembles Consolation Valley 1 (CV1) displaying a similar drainage induced pattern. However, CV1 occurs on morainal landforms rather than calcareous, fine textured glaciola-

Table 244 Pedon (Alberta 1977 No. 126) description of a Gleyed Eutric Brunisol of wet segments of the MC1 Ecosite.

CLASSIFICATION: CANADIAN SYSTEM OF THE YEAR 1978, SUBGROUP: GLEYED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: MC1.

LOCATION: MILITARY GRID REF. 11 UBN 2920 4280; NTS MAP AREA 83N 15E.

CLIMATE: 1760 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE.

VEGETATION: VMH-/07116.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), FLUVIOLACUSTRINE; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, CLAYEY (>35% CLAY), MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), GLACIOLACUSTRINE; PARENT MATERIAL 3: FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), WEAKLY CALCAREOUS (1 TO 6% CACO3), FLUVIOLACUSTRINE; LANDFORM CLASSIFICATION: GLACIO LACUSTRINE, VENEER; SLOPE: 8% COMPLEX SLOPE OF CLASS 4 (6-9%), FACING SOUTH, SITE AT TOE POSITION, 200 M LONG; SOIL MOISTURE AND DRAINAGE: POORLY DRAINED, SEEPAGE PRESENT, 0.2 M TO APPARENT WATERTABLE; SLIGHTLY STONY; HORROCKY.

SPECIAL NOTES: [illegible] LBV/MR

OH: 9 TO 0 CM, RANGE 9 TO 10 CM; MATRIX MOIST 5YR 2.5/1; ABUNDANT, VERY FINE AND FINE, RANDOM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AHGJ: 0 TO 6 CM, RANGE 1 TO 7 CM; MATRIX MOIST 10YR 5/2; SILTY CLAY LOAM; COMMON, COARSE, FAINT, 10YR 5/3 MOTTLES; WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; SLIGHTLY STICKY, VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE, RANDOM ROOTS; FEW, MICRO PORES; WAVY, CLEAR HORIZON BOUNDARY.

BFJGJ: 6 TO 15 CM, RANGE 5 TO 18 CM; MATRIX MOIST 7.5YR 5/4; SILT LOAM; FEW, MEDIUM, FAINT, 7.5YR 4/4 MOTTLES; VERY WEAK, SUBANGULAR BLOCKY STRUCTURE; VERY WEAK, PLATY SECONDARY STRUCTURE PSEUDO; FRIABLE CONSISTENCE; PLENTIFUL, MICRO AND FINE ROOTS; MANY, FINE PORES; WAVY, ABRUPT HORIZON BOUNDARY.

2BMGJ: 15 TO 40 CM, RANGE 23 TO 33 CM; MATRIX MOIST 10YR 7/2; SILTY CLAY; MANY, COARSE, DISTINCT, 10YR 5/3 MOTTLES; MODERATE, COARSE, COLUMNAR STRUCTURE; STICKY, PLASTIC CONSISTENCE; FEW, FINE ROOTS; COMMON, FINE PORES; FEW, THIN CLAY FILMS 10YR 7/2; GRAVELLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

3CKGJ: 40 TO 60 CM; MATRIX MOIST 10YR 6/3; LOAM; COMMON, MEDIUM, FAINT, 10YR 5/3 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; STICKY, PLASTIC CONSISTENCE; FEW, FINE PORES; WEAK EFFERVESCENCE; GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
OH	6.6	30.50	1.0						
AHGJ	6.6	10.90	0.9	65.6		54.6	9.8	0.1	0.3
BFJGJ	6.6	4.40	1.3	36.3		24.8	8.0	0.1	0.3
2BMGJ	6.8	0.30	0.6	9.7		6.1	2.7	0.6	0.2
3CKGJ	7.2		3.0						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
OH				
AHGJ				
BFJGJ	0.3		0.3	
2BMGJ	0.1		<.1	
3CKGJ				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
OH															
AHGJ										10		53	37	9	
BFJGJ										9		65	26	5	
2BMGJ										8		44	48	14	1.84
3CKGJ	99	87	78	64						39		39	22	4	2.13

PHYSICAL DATA

ENGINEERING

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
OH								
AHGJ								
BFJGJ								
2BMGJ								
3CKGJ	18.0	33.0		18.0	1.8		40	18

Table 245 Stand PA7107; illustrating the spruce-/Labrador tea/brown moss (011) v.t. of wet segments of the MC1 Ecosite.

TREE LAYER	
Picea complex	10
Pinus contorta	05
TALL SHRUB LAYER	
Picea complex	01
SHRUB LAYER	
Betula pumila	05
Ledum groenlandicum	15
Potentilla fruticosa	03
Salix glauca	03
HERB-DWARF SHRUB LAYER	
Arctostaphylos rubra	.5
Aster ciliolatus	.5
Campanula rotundifolia	01
Carex scirpoidea	.5
Carex vaginata	.5
Cornus canadensis	10
Deschampsia caespitosa	.5
Empetrum nigrum	03
Epilobium angustifolium	.5
Epilobium palustre	.5
Juncus albescens	.5
Juncus balticus	20
Juniperus communis	05
Erysepsis asperifolia	.5
Oxycoccus microcarpus	01
Pedicularis groenlandica	.5
Polygonum viviparum	.5
Rubus acaulis	.5
Senecio pauperculus	.5
Vaccinium vitis-idaea	.5
Equisetum arvense	02
Equisetum scirpoides	.5
BRYOID LAYER	
Aulacomnium palustre	35
Brachythecium turgidum	.5
Bryum pseudotriquetrum	.5
Campylium stellatum	.5
Cladonia mitis	05
Cratoneuron commutatum	.5
Dicranum scoparium	.5
Distichium capillaceum	.5
Hylocomium splendens	15
Hypnum bambergeri	.5
Meesia uliginosa	.5
Peltigera polydactyla	.5
Sphagnum capillaceum	01
Tomenthypnum nitens	20

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

custrine material. The Nashan 1 (NH1) Ecosite is the Montane counterpart of MC1. The majority of MC1 is mapped in the Mistaya and Pipestone River valleys in Banff.

ML - MORAINE LAKE ECOSECTION

The Moraine Lake Ecosection encompasses morainal landforms comprised of noncalcareous, coarse textured till (Till A) throughout the Lower Subalpine portion of the Subalpine Ecoregion in the Main Ranges of Banff and Jasper. It occurs primarily on valley walls in portions of main and tributary valleys that are geologically dominated by Cambrian Gog Group quartzites.

The dominant soils, Dystric Brunisols, reflect the acidic, coarse textured parent material in that they are deeply weathered and strongly eluviated. Three groups of coniferous forest vegetation differentiate the three Moraine Lake Ecosites (Table 246). Fig. 43 shows the ML1 and ML2 Ecosites in relation to their Upper Subalpine (LV1, LV2, LV3) and Alpine (EF1) counterparts.

ML1 - MORAINE LAKE 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, ML1, occurs on morainal blankets consisting of noncalcareous, coarse textured till (Till A) overlying inclined bedrock on valley walls. The dominant soils are (relative to others in the study area) deeply weathered, strongly eluviated Eluviated Dystric Brunisols. Orthic Humo-Ferric Podzols are subdominant and are associated with veneers of altered, medium textured eolian material (Eolian material B). Vegetation cover is dominated by the Engelmann spruce-subalpine fir/false azalea (C14), Engelmann spruce-subalpine fir/feathermoss (C13), and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s.

Geomorphology

The ML1 Ecosite is typified by morainal blankets overlying inclined bedrock on valley walls. These moraines consist of noncalcareous, coarse textured till (Till A) but include a low lime phase. Surface veneers of altered, medium textured eolian material (Eolian material B) are extensive over ML1 tracts of

Table 246 General features of the Moraine Lake (ML) Ecosites.

Ecosite	Landform	Soils	Vegetation
ML1	Till A; blanket	Dystric Brunisol > Podzolic	Engelmann spruce-subalpine fir forest
ML2	Till A; blanket	Dystric Brunisol	lodgepole pine forest
ML3	Till A; blanket	Dystric Brunisol	Engelmann spruce-whitebark pine forest

western Banff and southwestern Jasper, and are sporadic in northwestern Jasper. Colluvium derived from till and/or fractured bedrock is found occasionally on the steepest portions of the landscape. Ice contact stratified material occurs rarely.

Topographically, the ML1 Ecosite displays long linear slopes consisting of till mantling the inclined bedrock that forms valley walls. Slopes are normally 15 to 70%. Morainal veneers occur occasionally; bedrock outcrops rarely. Small localities dominated by colluvial blankets and veneers occur occasionally on the steepest terrain. The linear till slopes are often dissected by parallel gullies oriented perpendicular to the contour. Small fluvial fans and aprons may occur at gully mouths at a major break in slope (usually the valley bottom) and are included in ML1 tracts if too small to be delineated as fluvial Ecosites. Tracts mapped as ML1 situated along broad valley bottoms, at valley confluences, on failed slopes, and occasionally in valley headwall areas often have irregular surfaces with complex slopes (usually 5-45%). These landforms include morainal blankets overlying ridged or hummocky bedrock and the relatively deep till of hummocky moraines.

Soils

The dominant soils of ML1, well drained Eluviated Dystric Brunisols, have comparatively thick sola and thick, well developed, eluvial (Ae) horizons that reflect the acidity, rapid permeability, and coarse textures of the parent material. Where altered, medium textured eolian material is present, these Eluviated Dystric Brunisols usually have Bf horizons above and Bm horizons below the parent material disconformity and somewhat thinner Ae horizons. Intimately associated in this geomorphic setting are the subdominant Orthic Humo-Ferric Podzols that have podzolic Bf horizons above the parent material disconformity. Soils with Bhf and podzolic Bhf horizons also occur occasionally. Weak cementation in lower Bm or BC horizons below the parent material disconformity occurs often in ML1 soils. Orthic Dystric Brunisols occur in localities recently affected by erosional processes such as avalanching, gullying, or shallow surface colluviation. Some gullies contain seeps with which various wet soils are associated. Lithic soil phases occur occasionally.

A pedon illustrating Eluviated Dystric Brunisols of the ML1 Ecosite is described in Table 247. It differs from modal ML1 soils by its relatively high organic carbon content in the upper solum, high pH and lime content in the parent material. The carbonate is attributable to the localized presence of calcareous erratics in the noncalcareous, coarse textured till of the sampling area.

Vegetation

The ML1 Ecosite is dominated by the Engelmann spruce-subalpine fir/false azalea (C14), Engelmann spruce-subalpine fir/feathermoss (C13), and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s. Overall, C14 is most abundant but some ML1 tracts are dominated by C13 or C21. The C13 v.t. is more common along the eastern side of the Main Ranges and on gently sloping lower slopes below C14 or C21 dominated valley walls. The C21 v.t. is more abundant in northern Jasper along the Continental Divide, particularly where low passes dissect the Divide. Minor amounts of Engelmann spruce-whitebark pine/false azalea (C12) and Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) occur occasionally in west central and northern Jasper. Wet v.t.s such as Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14) are associated with seeps. Snow avalanche v.t.s such as subalpine fir-willow (S2) occur on avalanched portions. Fire affected vegetation in which spruce rather than pine is regenerating occurs in some areas (e.g. west of Sunwapta River opposite Beauty Creek in Jasper).

A stand that illustrates the C14 v.t. of the ML1 Ecosite is described in Table 248. This stand is located at about the same elevation on the same slope as the pedon sampling site but <1 km up valley. The occurrence of *Senecio triangularis* and *Erigeron peregrinus* suggests that the site is moister than modal for ML1.

Discussion

The ML1 Ecosite is the most extensive of the Moraine Lake Ecosites. In physiographic position, landform surface expression, and vegetation, ML1 resembles the Cavell 2 (CA2) and Bryant 1 and 2 (BY1, BY2) Ecosites. However, rather than the Till A associated with ML1, CA2 occurs on morainal landforms consisting of noncalcareous, medium textured till (Till B) and BY1 and BY2 occur on calcareous, medium textured till (Till C). Also BY1 and BY2 are dominated by Eutric Brunisols with thin sola rather than Dystric Brunisols. In addition to Eluviated Dystric Brunisols, CA2 has significant amounts of Orthic Dystric Brunisols. Soils of CA2 are not as deeply weathered and strongly eluviated as ML1 soils. The ML2 and ML3 Ecosites are differentiated from ML1 by their vegetation as outlined in Table 246.

ML2 - MORAINE LAKE 2 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, ML2, occurs on morainal blankets consisting of noncalcareous, coarse textured till (Till A) overlying

Table 247 Pedon (Alberta 1974 No. 124) description of an Eluviated Dystric Brunisol of the ML1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1970. SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: ML1.

LOCATION: MILITARY GRID REF. 11 UNG 8715 1985; NTS MAP AREA 82N 8E.

CLIMATE: 1985 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS MODERATE RELEVANCE TO THE SOIL SITE.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND SANDY, MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), MORAINAL (TILL), QUARTZITE; LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 26% SIMPLE SLOPE OF CLASS 6 (16-30%), FACING EAST, SITE AT LOWER SLOPE POSITION; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, RAPIDLY PERVIOUS, MODERATE SURFACE RUNOFF; EXCEEDINGLY STONY; NONROCKY.

SPECIAL NOTES: SSN=BW4080+PLU=15+BSC=ST+PCP=1GR(2)SGR+CB(3)SGR+CB+ST(4-7)+ALSO 5YR4/7 COLORS IN BHF+ BC2 LIGHTER COLOR THAN C HORIZON+ BC2 HORIZON BRITTLE+ PROFILE REPRESENTATIVE OF COARSE TEXTURED,NONCALCAREOUS TILL IN THE LOWER SUBALPINE+ INFILTRATION RATE=42 CM/HR+PERCOLATION RATE=0.3 MIN/CM+LFH=MB/BI+AP!=783-61+

LF: 4 TO 0 CM, RANGE 1 TO 0 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/1; ABUNDANT, MEDIUM AND COARSE, RANDOM ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 6 CM, RANGE 3 TO 12 CM; HORIZON MOIST; CRUSHED DRY 10YR 7/1; SILT LOAM; WEAK, MEDIUM TO COARSE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MEDIUM AND COARSE, RANDOM ROOTS; GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BHF: 6 TO 12 CM, RANGE 2 TO 11 CM; HORIZON MOIST; MATRIX MOIST 2.5YR 4/6, MATRIX MOIST 7.5YR 5/8; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; WEAK, FINE, GRANULAR SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MEDIUM AND COARSE, RANDOM ROOTS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

2BM: 12 TO 32 CM, RANGE 12 TO 30 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6, MATRIX DRY 7.5YR 6/6; GRAVELLY LOAMY SAND; STRUCTURELESS, MASSIVE STRUCTURE; WEAK, FINE, GRANULAR SECONDARY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, MEDIUM AND COARSE, RANDOM ROOTS; GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2BC1: 32 TO 57 CM, RANGE 20 TO 30 CM; HORIZON MOIST; GRAVELLY SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; FRIABLE AND FIRM CONSISTENCE; WEAKLY CEMENTED; PLENTIFUL, MEDIUM AND FINE, RANDOM ROOTS; GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; SMOOTH, GRADUAL HORIZON BOUNDARY.

2BC2: 57 TO 90 CM; HORIZON DRY; GRAVELLY FINE SANDY LOAM AND LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; HARD CONSISTENCE; WEAKLY CEMENTED; FEW, MEDIUM AND FINE, VERTICAL ROOTS; GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; SMOOTH, CLEAR HORIZON BOUNDARY.

2CX: 90 TO 100 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/6; GRAVELLY LOAMY SAND; LOOSE CONSISTENCE; VERY FEW, FINE, VERTICAL ROOTS; GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.5	41.30		69.5		23.1	5.5	-.1	1.6
AE	5.8	2.40		13.4		8.8	0.4	0.1	0.2
BHF	4.8	5.70		36.2		8.4	0.3	-.1	0.5
2BM	5.3	1.10		7.8		0.8	0.0	0.1	0.1
2BC1	4.9			3.5		0.5	0.0	0.0	0.1
2BC2	5.4			2.7		1.4	0.3	0.0	0.1
2CX	7.1		14.6	1.7		3.3	0.5	-.1	0.1

SPECIAL ANALYTICAL DATA

HORIZON	INFILTRATION RATE, STEADY STATE (CM/HR)	SATURATED HYDRAULIC CONDUCTIVITY (CM/HR)
LF	42.0	
AE		
BHF		
2BM		
2BC1		
2BC2		
2CX		

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 75-2U SILT	% OF SAMPLE 80-2U SILT	2U CLAY	0.2U CLAY
LF														
AE					1	2	3	19	9	85		69	6	1
BHF					4	5	8	12	11	40		83	7	0
2BM					9	10	19	27	12	77		19	4	0
2BC1					8	13	19	28	9	69		28	3	0
2BC2					9	14	23	22	8	76		17	7	1
2CX		99	94	47	28	9	14	24	23	9	79		16	5	1

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AE								
BHF								
2BM								
2BC1								
2BC2								
2CX	0.0	0.0					11	GR

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BHF	0.4		1.0	
2BM	0.1		0.2	
2BC1				
2BC2				
2CX				

Table 248 Stand (KS5052) illustrating the Engelmann spruce-subalpine fir/false azalea (C14) v.t. of the ML1 Ecosite.

TREE LAYER	
Picea engelmannii	45
Pinus contorta	05
TALL SHRUB LAYER	
Picea engelmannii	03
SHRUB LAYER	
Abies lasiocarpa	04
Ledum groenlandicum	03
Menziesia glabella	60
Picea engelmannii	05
Salix vestita	02
Vaccinium membranaceum	02
HERB-DWARF SHRUB LAYER	
Aquilegia flavescens	.5
Arnica cordifolia	10
Calamagrostis canadensis	.5
Carex media	.5
Elymus innovatus	.5
Epilobium angustifolium	.5
Erigeron peregrinus	.5
Fragaria virginiana	.5
Hieracium albiflorum	.5
Petasites palmatus	.5
Pyrola secunda	.5
Senecio triangularis	02
Solidago decumbens	.5
Vaccinium scoparium	30
Equisetum scirpoides	.5
Lycopodium annotinum	05
BRYOID LAYER	
Aulacomnium palustre	.5
Cladonia ecmocyna	03
Brachythecium frigidum	.5
Dicranum fuscescens	.5
Dicranum scoparium	20
Drepanocladus uncinatus	.5
Hylocomium splendens	02
Peltigera aphthosa	06
Peltigera canina	.5
Pleurozium schreberi	25
Pohlia nutans	.5
Polytrichum juniperinum	03
Stereocaulon tomentosum	.5
Barbilophozia hatcheri	10
Lophozia ventricosa	.5
Icmadophila ericetorum	.5
EPIPHYTES	
Alectoria sp.	.5
Usnea sp.	.5
Hypogymnia sp.	.5
Parmelia sp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

inclined bedrock on valley walls. The dominant soils are deeply weathered, strongly eluviated Eluviated Dystric Brunisols. Vegetation cover is dominated by the lodgepole pine/buffaloberry/grouseberry (C18) and lodgepole pine/false azalea/grouseberry (C20) v.t.s. The ML2 Ecosite is more extensive in Jasper than in Banff.

Geomorphology

The ML2 Ecosite is typified by morainal blankets overlying inclined bedrock on valley walls. These moraines consist of Till A. Colluvium derived from till and/or fractured bedrock is found occasionally of the steepest portions of the landscape. Ice contact stratified material occurs rarely, although the landform pattern and textural characteristics of material observed along the upper Brazeau River below Four Point Creek in Jasper may be the result of ice margin stream erosion. Although ML2 is usually associated with Cambrian Gog Group quartzites, an ML2A tract located north of Cascade Mountain in Banff is associated with quartz sandstone of the Rocky Mountain Group. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically. Most ML2 tracts, excepting those at the southern end of the Wapituk Range in Banff, are located outside the area of extensive Eolian material B veneers and erosion subsequent to fires has removed much of the deposit.

Topographically, the ML2 Ecosite displays long linear slopes consisting of till mantling the inclined bedrock that forms valley walls. Slopes are normally 15 to 70%. Morainal veneers occur occasionally and bedrock outcrops rarely except in tracts mapped as ML2X such as those located in the Athabasca River valley below Lick Creek in Jasper. These tracts have morainal veneers, lithic soils, and some bedrock escarpments. Small localities dominated by colluvial blankets and veneers occur occasionally on the steepest terrain. The linear till slopes are often dissected by parallel or subparallel gullies oriented perpendicular to the contour. Small fluvial fans and aprons may occur at gully mouths at a major break in slope (usually the valley bottom) and are included in ML2 tracts if they are too small to delineate as fluvial Ecosites. Tracts mapped as ML2 situated along broad valley bottoms, at valley confluences, and on failed slopes often have irregular surfaces with complex slopes (5-45%). These landforms include morainal blankets overlying ridged or hummocky bedrock and the relatively deep till of hummocky moraines.

Soils

The dominant soils of ML2, well drained Eluviated Dystric Brunisols, have thick sola and thick, well developed, eluvial (Ae) horizons that reflect the acidity, rapid permeability, and coarse textures of the parent material. Weak cementation in lower Bm or BC horizons is a common feature. Orthic Dystric Brunisols occur in localities recently affected by erosional processes such as avalanching, gullying, or shallow surface colluviation. Some gullies contain seeps with which wet soils are associated. Where altered, medium textured eolian material is present, Eluviated Dystric Brunisols and Orthic Humo-Ferric Podzols occur. These soils have

Table 249 Pedon (Alberta 1979 No. 60) description of an Eluviated Dystric Brunisol of the ML2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: ML2.

LOCATION: MILITARY GRID REF. 11 UMJ 4745 3445; NTS MAP AREA 83C 12*.

CLIMATE: 1850 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 9 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: VPN=JE9162* VTH=C20 *.

SOIL SITE: PARENT MATERIAL 1: COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), MORAINAL (TILL), QUARTZITE; LANDFORM CLASSIFICATION: MORAINAL; GULLIED; SLOPE: 47% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING SOUTHWEST; SITE AT MIDDLE POSITION, SLIGHTLY ROUNDED MICROTOPOGRAPHY,400 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; SLIGHTLY STONY; NONROCKY.

SPECIAL NOTES: SSN=GS9178*APN=015-063*PCF=3GR,3CB(1-4)3GR,3CB,3ST(5-8)*VERY COMPACTED TILL*DATE=AUG.28,1979*LFH=MB/RI*

LF: 4 TO 0 CM, RANGE 6 TO 4 CM; HORIZON MOIST; MATRIX MOIST 5YR 6/1; ABUNDANT, FINE AND MEDIUM, RANDOM ROOTS; 40% ANGULAR GRAVELLY AND COBBLY COARSE FRAGMENTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

AE1: 0 TO 17 CM, RANGE 14 TO 20 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 6/2; GRAVELLY FINE SANDY LOAM; WEAK, COARSE, PLATY STRUCTURE; PLENTIFUL, FINE AND MEDIUM, OBLIQUE ROOTS; COMMON, MEDIUM PORES; 40% ANGULAR GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

AE2: 17 TO 31 CM, RANGE 13 TO 15 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 6/4; GRAVELLY LOAMY SAND; VERY WEAK, COARSE, PLATY STRUCTURE; PLENTIFUL, FINE AND MEDIUM, OBLIQUE ROOTS; COMMON, MEDIUM PORES; 40% ANGULAR GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, DIFFUSE HORIZON BOUNDARY.

AB: 31 TO 38 CM, RANGE 3 TO 9 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/8; GRAVELLY LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; FEW, VERY FINE AND FINE, VERTICAL ROOTS; 40% ANGULAR GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

BM: 38 TO 55 CM, RANGE 14 TO 18 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6; GRAVELLY FINE SANDY LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FEW, VERY FINE ROOTS; VERY FEW, VERY FINE PORES; 40% ANGULAR GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; IRREGULAR, GRADUAL HORIZON BOUNDARY.

BMC: 55 TO 71 CM, RANGE 14 TO 18 CM; HORIZON MOIST; MATRIX MOIST 5YR 5/4; GRAVELLY SANDY LOAM; MODERATE TO STRONG, MEDIUM TO COARSE, SUBANGULAR BLOCKY STRUCTURE; VERY FEW, MICRO ROOTS; VERY FEW, FINE PORES; 40% ANGULAR GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; SMOOTH, DIFFUSE HORIZON BOUNDARY.

BC: 71 TO 90 CM, RANGE 18 TO 21 CM; HORIZON MOIST; MATRIX MOIST 5YR 6/6; GRAVELLY FINE SANDY LOAM; WEAK TO MODERATE, MEDIUM TO COARSE, SUBANGULAR BLOCKY STRUCTURE; MODERATELY POROUS, FEW, MEDIUM PORES; 40% ANGULAR GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; SMOOTH, DIFFUSE HORIZON BOUNDARY.

C: 90 TO 100 CM; HORIZON MOIST; MATRIX MOIST 5YR 5/4; GRAVELLY FINE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; MODERATELY POROUS, FEW, MEDIUM PORES; 40% ANGULAR GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	3.8	32.60						
AE1	4.8	8.90	5.4		1.6	0.3	-.1	0.1
AE2	4.9	0.10	3.2		0.8	0.3	0.1	-.1
AB	4.6	0.20	2.6		0.7	0.1	-.1	-.1
BM	5.6	0.20	1.7		1.0	0.1	-.1	-.1
BMC	5.3	0.50	3.5		0.7	0.2	-.1	0.1
BC	4.9		1.4		0.3	0.0	-.1	0.1
C	4.6		1.9		0.6	0.1	-.1	0.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE1				
AE2				
AB				
BM	0.1		-.1	
BMC	0.1		0.1	
BC				
C				

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE1					5	7	17	23	9	61		36	3	
AE2					5	8	20	29	11	73		25	2	
AB					3	8	22	31	11	75		21	4	
BM					4	6	15	23	8	56		34	8	
BMC					5	8	17	29	2	61		32	7	
BC					5	6	15	23	11	60		31	9	
C	99	77	67	63	3	6	13	23	10	55		33	12	

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY ( )	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AE1								
AE2								
AB								
BM								
BMC								
BC								
C	18.8	31.8					A4	ML

thinner Ae horizons and Bf or podzolic Bf horizons above and Bm horizons below the parent material disconformity. The ML2 tracts situated at the southern end of the Waputik Range in Banff have significant amounts of these soils. Lithic soil phases are not common except on ML2X tracts, such as those located in the Athabasca River valley below Lick Creek in Jasper, where they dominate.

A pedon illustrating Eluviated Dystric Brunisols of the ML2 Ecosite is described in Table 249. Color Plate 41 shows the upper solum of this pedon. It differs from modal ML2 soils by its fine texture in the C horizon. This phenomenon occurs occasionally in this noncalcareous, coarse textured till.

Vegetation

The ML2 Ecosite is dominated by the lodgepole pine/buffaloberry/grouseberry (C18) and lodgepole pine/false azalea/grouseberry (C20) v.t.s that reflect the predominant southerly aspects and fire history. Accessory v.t.s include lodgepole pine/green alder/feathermoss (C10), lodgepole pine/feathermoss (C11), and lodgepole pine/buffaloberry/twinflower (C19). Occasionally lodgepole pine/buffaloberry/showy aster (C6) occurs on drier localities. Avalanched and severely fire affected vegetation occurs in some localities.

A stand that illustrates the C20 v.t. of the ML2 Ecosite is described in Table 250. This stand is located above Honeymoon Lake in Jasper < 15 km southeast of the ML2 pedon sample site.

Discussion

In physiographic position, landform surface expression and vegetation, ML2 resembles the Cavell 4 (CA4) and Panorama Ridge 1 and 2 (PR1, PR2) Ecosites. However, rather than the Till A of ML2, CA4 occurs on morainal landforms consisting of noncalcareous, medium textured till (Till B), and PR1 and PR2 occur on calcareous, medium textured till (Till C). Also, PR1 and PR2 are dominated by Eutric Brunisols with thin sola and luvisolic tendencies rather than Dystric Brunisols. In addition to Eluviated Dystric Brunisols, CA4 has significant amounts of Orthic Dystric Brunisols. The ML1 and ML3 Ecosites are differentiated from ML2 by vegetation as outlined in Table 246.

Table 250 Stand (1C6003) illustrating the lodgepole pine/false azalea/grouseberry (C20) v.t. of the ML2 Ecosite.

TREE LAYER	
Picea engelmannii	.5
Pinus contorta	35
TALL SHRUB LAYER	
Alnus crispa	05
Picea mariana	.5
SHRUB LAYER	
Juniperus communis	.5
Menziesia glabella	10
Rhododendron albiflorum	01
HERB-DWARF SHRUB LAYER	
Arnica cordifolia	.5
Cornus canadensis	.5
Epilobium angustifolium	.5
Linnaea borealis	.5
Lycopodium complanatum	.5
Pyrola secunda	.5
Pyrola virens	.5
Spiraea lucida	.5
Vaccinium membranaceum	05
Vaccinium scoparium	40
BRYOID LAYER	
Cladonia spp.	02
Dicranum spp.	.5
Hylocomium splendens	20
Pleurozium schreberi	35
Polytrichum commune	.5
Ptilium crista-castrensis	01

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

ML3 - MORAINE LAKE 3 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, ML3, occurs on morainal blankets consisting of noncalcareous, coarse textured till (Till A) overlying inclined bedrock. The dominant soils are deeply weathered, strongly leached Eluviated Dystric Brunisols. Vegetation cover is dominated by the Engelmann spruce-whitebark pine/false azalea (C12) v.t. The ML3 Ecosite is found only in Jasper in the area bounded by Highway 16 to the north, Highway 93 to the east, and the Athabasca and Chaba Rivers to the south. It is restricted to altitudes just below the Upper Subalpine - Lower Subalpine boundary.

Geomorphology

The ML3 Ecosite is typified by morainal blankets overlying inclined bedrock. Colluvium and ice contact stratified drift occur rarely. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically. Most ML3 tracts are located outside the area of extensive Eolian material B veneers and erosion has removed much of the deposit.

Topographically, the ML3 Ecosite displays long linear slopes consisting of till mantling the inclined bedrock of northerly or northeasterly oriented spurs that separate large valleys. The ML3 tract at Geraldine Lookout is a good example. Thinner till deposits resulting

in morainal veneers frequently occur along spur ridge crests. A large tract in the Astoria River valley forms part of the valley wall. Occasionally, complex topography occurs where the bedrock surface is hummocky or on failed slopes, such as the ML3F tract below Verdant Pass in the Whirlpool River valley. Slopes normally range from 30 to 70%. The linear till slopes are often dissected by parallel or subparallel gullies oriented perpendicular to the contour.

Soils

The dominant soils of ML3 are well drained Eluviated Dystric Brunisols with thick sola and thick, well developed, eluvial (Ae) horizons that reflect the acidity, rapid permeability, and coarse textures of the parent material. Weak cementation in lower Bm or BC horizons is a common feature. Orthic Dystric Brunisols occur in localities recently affected by erosional processes such as gullying or shallow surface colluviation. Where altered, medium textured eolian material is present, Eluviated Dystric Brunisols and Orthic Humo-Ferric Podzols occur. These soils have thinner Ae horizons and Bf or podzolic Bf horizons above and Bm horizons below the parent material disconformity. Lithic phases are not common except locally along ridge crests. The pedon described in Table 249 for the ML2 Ecosite also illustrates soils of ML3.

Vegetation

The ML3 Ecosite is dominated by the Engelmann spruce-whitebark pine/false azalea (C12) v.t. Factors involved in this dominance of C12 are not apparent, because ML1 tracts dominated by Engelmann spruce-subalpine fir/false azalea (C14) or Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) also occur on similar landscape positions throughout the area containing ML3 tracts. Occurences of ML3 have a narrow elevational range, and all ML3 tracts are bounded above by Upper Subalpine Ecosite tracts. A stand illustrating the C12 v.t. of the ML3 Ecosite is described in Table 251.

Discussion

The ML3 Ecosite is the least extensive of the Moraine Lake Ecosites and is of very limited extent relative to the study area. In terms of geographic distribution, physiographic position, landform, genetic material, and soils, ML3 most closely resembles the ML1 Ecosite. Vegetation separates the two: ML3 being dominated by Engelmann spruce-whitebark pine/false azalea (C12), whereas ML1 is dominated by Engelmann spruce-subalpine fir/false azalea (C14), Engelmann spruce-subalpine fir/feathermoss (C13), and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21). The C12 v.t. also occurs locally on other Ecosites, particularly on rocky or stony (bouldery) sites within various Upper Subalpine Ecosite tracts. The ML3 Ecosite does not, however, have unusually rocky or stony soils.

Table 251 Stand (IC5073) illustrating the Engelmann spruce-whitebark pine/false azalea (C12) v.t. of the ML3 Ecosite.

TREE LAYER	
Abies lasiocarpa	20
Picea engelmannii	10
Pinus albicaulis	05
SHRUB LAYER	
Ledum groenlandicum	.5
Menziesia glabella	75
Rhododendron albiflorum	05
Sorbus scopulina	.5
HERB-DWARF SHRUB LAYER	
Cornus canadensis	01
Empetrum nigrum	.5
Phyllodoce empetriformis	.5
Pyrola secunda	.5
Vaccinium membranaceum	01
Vaccinium scoparium	01
Vaccinium vitis-idaea	.5
BRYOID LAYER	
Barbilophozia lycopodioides	.5
Calypogeia neesiana	.5
Cephaloziella spp.	.5
Cladonia carneola	.5
Cladonia cenotea	.5
Cladonia chlorophaea	.5
Cladonia ecmocyna	.5
Cladonia gonecha	.5
Cladonia mitis	.5
Cladonia phyllophora	.5
Dicranum fuscescens	.5
Dicranum muehlenbeckii	.5
Dicranum scoparium	.5
Hylocomium splendens	40
Icmadophila ericetorum	.5
Lophozia spp.	.5
Peltigera aphthosa	01
Pleurozium schreberi	35
Pohlia nutans	.5
Ptilium crista-castrensis	03
EPIPHYTES	
Bryoria fremontii	.5
Cetraria pinastri	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

MP - MOLAR PASS ECOSECTION

The Molar Pass Ecosection encompasses morainal landforms comprised of calcareous, medium textured till (Till C) in the Alpine Ecoregion throughout Banff and Jasper. The MP Ecosection occurs on valley walls and shoulders, cirque basins, and cols, and is associated with calcareous strata. Eutric and Melanic Brunisols, Regosols, and Humic Regosols characterize the soil component of

Table 252 General features of the Molar Pass 1 (MP1) Ecosite.

Ecosite	Landform	Soils	Vegetation
MP1	Till C; blanket, veneer	Eutric and Melanic Brunisol, Regosol, Humic Regosol	mountain avens tundra, heath tundra

MP1. Brunisolic soils are most abundant. Soil distribution reflects the degree of surface stability and weathering of calcareous material and the presence of veneers of altered, medium textured eolian material (Eolian material B). The vegetation component is dominated by mountain avens and heath tundra, the mountain avens tundra being more abundant. Table 252 summarizes the characteristics of the one Molar Pass Ecosite (MP1). Fig. 48 shows, schematically, the position of MP1 in relation to the Peyto Lake (PL) and Sphinx (SX) Ecosites.

MP1 - MOLAR PASS 1 ECOSITE

Ecosite Concept

The Alpine Ecosite, MP1, occurs on morainal blankets and veneers consisting of calcareous, medium textured till (Till C) overlying inclined, hummocky, and ridged bedrock. Soil distribution depends on the degree of surface stability and weathering of calcareous material, and the distribution of veneers of altered, medium textured eolian material (Eolian material B). The dominant soils are Orthic Eutric Brunisols, Orthic Melanic Brunisols, Orthic Regosols, and Orthic Humic Regosols with the Brunisolic soils being most abundant. Vegetation cover is dominated by the mountain avens-snow willow-moss campion (H1) and heather-everlasting (L5) v.t.s with H1 being more abundant in most areas.

Geomorphology

The MP1 Ecosite is typified by morainal blankets and veneers overlying inclined, hummocky, or ridged bedrock. These moraines consist of calcareous, medium textured till (Till C). Veneers of altered, medium textured eolian material (Eolian material B) are most extensive on MP1 tracts of western Banff and southwestern Jasper except on exposed, wind-swept tracts (e.g. Allenby Pass in Banff). In other areas Eolian material B veneers occur sporadically and are very shallow. Colluvium derived from till and fractured bedrock is found occasionally on steepest portions of the landscape.

Topographically, MP1 is typified by inclined slopes on valley walls and hummocky or ridged surfaces on valley shoulders, cirque basins, and cols. Bedrock control of surface expression is characteristic. Failed slopes, including old rock glaciers and severely soliflucted slopes, are common (mapped as MP1F) and usually have hummocky surfaces that do not necessarily reflect underlying bedrock. Slopes commonly range from 5 to 45% but a few tracts with steeper slopes occur. Some of the more steeply sloping tracts are dissected by gullies. Morainal veneers dominate on those tracts mapped as MP1X. Bedrock outcrops occur sporadically but are abundant on MP1+R tracts. Colluvial blankets and veneers occur locally on the steepest terrain, particularly below bedrock escarpments.

Soils

Well to moderately well drained Orthic Eutric Brunisols, Orthic Melanic Brunisols, Orthic Regosols, and Orthic Humic Regosols dominate the MP1 Ecosite. The Brunisolic soils are most abundant and occur on geomorphically stable localities. The Regosolic soils occur on exposed, wind-swept localities lacking veneers of altered, medium textured eolian material (Eolian material B), on severely soliflucted or cryoturbated localities and on very shallow parent material. Regosolic soils dominate on some MP1 tracts that are extensively and severely cryoturbated (e.g. southwest of Mount McConnell in Banff; Plate 137 and Color Plate 42) or that have extensive, extremely shallow parent material in combination with exposed physiographic positions (e.g. Allenby Pass). The Regosolic soils usually occur under mountain avens-snow willow-moss campion (H1) vegetation, rarely with heather-everlasting (L5). Accessory and included v.t.s occasionally have Regosolic soils.

Both Brunisolic and Regosolic soil groups display, under Alpine conditions, humus accumulation in upper sola. Thus, MP1 soils have varying thicknesses of Ah and/or Ahe horizons. In the Brunisolic soils, this accumulation and translocation of humic material usually masks the effects of eluviation, although Eluviated Eutric Brunisols occur as accessory soils on locally stable sites. Normally Bm horizons display humus accumulation but are otherwise weakly to moderately developed. Where veneers of altered, medium textured eolian material (Eolian material B) are present, the soils often have strongly developed Bm, Bhf or podzolic Bhf horizons above, and weakly developed Bm or BC horizons below the parent material disconformity. Orthic Ferro-Humic Podzols are accessory soils and are most abundant in western Banff and southwestern Jasper. Soils with Bf and

Table 253 Pedon (Alberta 1979 No. 92) description of an Orthic Eutric Brunisol of the MP1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ONTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: MP1.

LOCATION: MILITARY GRID REF. 11 UNH 8450 1120; NTS MAP AREA 82O 1EH.

CLIMATE: 2270 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JD9083=VTN=H1=.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED AND MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), MORAINAL (TILL), SEDIMENTARY; LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 6% SLOPE OF CLASS 4 (6-9%), FACING EAST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,300 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; SLIGHTLY ROCKY.

SPECIAL NOTES: SSN=NT9151=APN=010-164=RLU=15=FCF=1A6R,1ACD(2-3)3A6R,3ACD,2BR,2CB(4-5)BA6R,2BR,4ACD,2CD,2ST(6)=LFH=EV/MB/RIH=SURFACE SLIGHTLY CRYOTURBATED=DATE=SEPT.6,1979=CRYOTURBATED SOILS COMMON ON TRACT=

LF: 3 TO 0 CM, RANGE 1 TO 4 CM; MATRIX MOIST 10YR 2/2; WAVY, CLEAR HORIZON BOUNDARY.

AH: 0 TO 3 CM, RANGE 2 TO 6 CM; MATRIX MOIST 7.5YR 2/1; SILT LOAM; WEAK, VERY FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

BM: 3 TO 14 CM, RANGE 9 TO 14 CM; MATRIX MOIST 7.5YR 5/6; SILT LOAM; VERY WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE AND MICRO ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

2BCK: 14 TO 21 CM, RANGE 7 TO 9 CM; MATRIX MOIST 10YR 4/2; CLAY LOAM; WEAK TO MODERATE, FINE, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; FEW, FINE ROOTS; WEAK EFFERVESCENCE; MODERATELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

2CK1: 21 TO 50 CM, RANGE 25 TO 32 CM; MATRIX MOIST 10YR 5/2; LOAM; WEAK TO MODERATE, MEDIUM, SUBANGULAR BLOCKY STRUCTURE PSEUDO; FRIABLE CONSISTENCE; VERY FEW, FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, GRADUAL HORIZON BOUNDARY.

2CK2: 50 TO 80 CM; MATRIX MOIST 10YR 4/1; GRAVELLY LOAM; MODERATE TO STRONG, MEDIUM, ANGULAR BLOCKY STRUCTURE PSEUDO; FRIABLE CONSISTENCE; STRONG EFFERVESCENCE; STRONGLY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	6.0	32.30							
AH	5.7	12.10		23.6		20.8	2.7	0.1	0.2
BM	6.2	3.00		43.6		16.3	2.2	0.2	0.1
2BCK	7.1		7.9						
2CK1	7.5		44.5						
2CK2	7.5		20.8						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AH				
BM	0.2		0.1	
2BCK				
2CK1				
2CK2				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 76-2U SILT	% OF SAMPLE 50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF															
AH										22		61	17		
BM										19		70	11		
2BCK										25		46	29		
2CK1										40		44	16		
2CK2	99	90	62	54						46		36	18		2.00

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AH								
BM								
2BCK								
2CK1								
2CK2	14.0	21.0		11.0	2.0		24	18

podzolic Bf horizons and Sombric Ferro-Humic Podzols also occur occasionally. Some Bm horizons developed in the till may show the rudimentary luvisolic tendencies (clay increases) associated with weathering of calcareous materials.

Lithic soil phases are associated with morainal veneers. These dominate on MP1X tracts. Turbic phases of MP1 soils, produced by solifluction and cryoturbation, are common, particularly on moderately well to imperfectly drained localities with seepage (Plate 138). Physical thickening, rearrangement, mixing, and disruption of upper sola horizons are manifestations of solifluction and cryoturbation processes (Color Plate 43). Regosolic soils are associated with severely soliflucted, cryoturbated, and colluviated localities. Imperfectly drained, Gleyed Brunisolic, Podzolic, and Regosolic soils occur locally on seepage affected sites.

A pedon illustrating Orthic Eutric Brunisols of MP1 is described in Table 253 and shown in Color Plate 44. This profile displays two phases of calcareous, medium textured till (Till C); the lower, darker colored one contains a significant amount of material derived from the underlying Mesozoic strata. The lower till has an abnormally high coarse fragment content that is attributed to its nearness to the source and short distance over which the till materials have been transported by ice.

Vegetation

The vegetation of MP1 is dominated by the mountain avens-snow willow-moss campion (H1) and heather-everlasting (L5) v.t.s. Usually H1 is most abundant, particularly in eastern portions of Banff and Jasper on exposed tracts, on tracts with shallow parent material, and on cryoturbated and soliflucted tracts. The L5 v.t. occurs on more sheltered, stable slopes where snow accumulation is greater. It is dominant on many MP1 tracts of high snowfall areas, e.g. western Banff and Jasper. Important accessory v.t.s are white mountain heather-mountain avens-snow willow (L4) and hairy wild rye-junegrass-bearberry (H14). The L4 v.t. occurs in late snow lie localities. Black alpine sedge-everlasting (H2) occurs occasionally in yet later snowbeds. The H14 v.t. is common on subxeric, steeply sloping localities with southerly aspects, usually on morainal landforms associated with Mesozoic strata in eastern Banff and Jasper. The mountain avens-kobresia-bearberry (H4) v.t. occurs in minor amounts under conditions similar to those for H14 but at higher elevations. Tracts of MP1 and with H14 and H4 usually are bounded below by tracts of Tyrrell 1 or 2 (TR1, TR2). Seepage affected sites have moist v.t.s such as arctic willow-cinquefoil (L7) and fleabane-valerian (H16). Up to 20% krummholz and tree islands are included along lower boundaries of some MP1 tracts. A stand representing vegetation of the pedon sample site described above (Table 253) and illustrating H1 on MP1 is presented in Table 254 and Plate 139.

Table 254 Stand (JD9083) illustrating the mountain avens-snow willow-moss campion (H1) v.t. of the MP1 Ecosite.

	HERB-DWARF SHRUB LAYER
Androsace chamaejasme	.5
Anemone drummondii	.5
Arenaria spp.	.5
Astragalus alpinus	.5
Carex atrosquama	01
Carex rupestris	01
Cassiope tetragona	.5
Castilleja occidentalis	.5
Dryas octopetala	60
Erigeron aureus	.5
Festuca brachyphylla	.5
Kobresia myosuroides	05
Luzula spicata	.5
Oxytropis podocarpa	02
Pedicularis lanata	.5
Phyllodoce glanduliflora	.5
Picea engelmannii	.5
Poa alpina	.5
Polygonum viviparum	01
Potentilla diversifolia	.5
Salix nivalis	15
Senecio lugens	.5
Silene acaulis	.5
Smelowskia calycina	.5
Solidago multiradiata	.5
Trisetum spicatum	01
Selaginella spp.	.5
	BRYOID LAYER
Cetraria cucullata	02
Cetraria ericetorum	04
Cetraria nivalis	09
Cetraria tilesii	.5
Cladonia sp.	.5
Grimmia apocarpa	.5
Lecanora polytropa	.5
Lecidella stigmatea	.5
Myurella julacea	.5
Peltigera rufescens	.5
Pohlia cruda	.5
Saelania glaucescens	.5
Solorina spongiosa	.5
Stereocaulon alpinum	.5
Thamnolia subuliformis	.5
Tortella tortuosa	.5
Tortula ruralis	01
Xanthoria elegans	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

In terms of physiographic position, landform surface expression and vegetation cover, MP1 resembles the Jonas 1 (JN1) and Eiffel 1 (EF1) Ecosites. However, JN1 in contrast to the calcareous Till C of MP1 occurs on morainal landforms consisting of noncalcareous, medium textured till (Till B) and EF1 occurs on noncalcareous, coarse textured till (Till A). Also both JN1 and EF1 are dominated by acidic, well developed soils, including Podzols. Regosolic soils occur less frequently on EF1 and JN1 than on MP1. Mountain avens-snow willow-moss campion

(H1) v.t. is less abundant on JN1 than on MP1. In contrast to MP1, the H1 occurs only occasionally, as an accessory v.t. on EF1. The Peyto Lake 4 (PL4) Ecosite is the Upper Subalpine counterpart of MP1.

MQ - MOSQUITO ECOSECTION

The Mosquito (MQ) Ecosection occurs on fluvial landforms (fans and aprons) comprised primarily of calcareous, coarse, stratified fluvial material (Fluvial material B), occasionally of noncalcareous, coarse, stratified fluvial material (Fluvial material A). It is dominated by Brunisolic and Regosolic soils associated with Engelmann spruce - subalpine fir open and closed forests. Modification by channeling (Eroded modifier, C.S.S.C. 1978b) is a common feature.

The MQ Ecosection occurs on lower slopes and valley floors in the Upper Subalpine portion of the Subalpine Ecoregion in Banff and Jasper.

Only one Ecosite (MQ1) is recognized within the MQ Ecosection. Table 255 outlines the general features of the MQ1 Ecosite.

MQ1 - MOSQUITO 1 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, MQ1, occurs on relatively stable fluvial fans and aprons comprised primarily of calcareous, coarse, stratified fluvial material (Fluvial material B), occasionally of noncalcareous, coarse, stratified fluvial material (Fluvial material A). Modification of these landforms by channeling is common. Well to moderately well drained Orthic and Eluviated Eutric Brunisols and Orthic Regosols dominate the MQ1 Ecosite. Orthic and Eluviated Eutric Brunisols are most abundant. Vegetation is characterized by the Engelmann spruce-subalpine fir/grouseberry (C15), and Engelmann spruce-subalpine fir/heather (O10) v.t.s, with C15 most abundant.

This Ecosite is widely distributed in the Upper Subalpine, but with limited extent in any area.

Geomorphology

The MQ1 Ecosite is characterized by fans and aprons comprised primarily of calcareous, coarse, stratified fluvial material (Fluvial material B), occasionally of noncalcareous, coarse, stratified fluvial material (Fluvial material A). Modification by channeling is common. Surficial veneers of altered, medium textured eolian material (Eolian material B) occur occasionally but are most common on MQ1 tracts located in western Banff and southwestern Jasper. They may also be water reworked eolian material. Other fluvial landforms occasionally found in MQ1 tracts include veneers and terraces. Veneers usually overlie morainal landforms.

Topographically, MQ1 has linear slopes commonly ranging from 5 to 45%.

Soils

The MQ1 Ecosite is dominated by well to moderately well drained Orthic and Eluviated Eutric Brunisols, with fewer tracts dominated by Orthic Regosols. The degree of development of the Brunisolic soils reflects geomorphic stability. The well developed Bm and Bf horizons of these soils are associated with local occurrences of altered, medium textured eolian material (Eolian material B) or water reworked eolian material. Orthic Regosols and minor amounts of Cumulic Regosols occur on entire tracts or near channels that are subject to episodic flooding, or modified by snow avalanching (MQ1A). Orthic Dystric Brunisols occur occasionally and are associated with the few tracts found on noncalcareous, coarse, stratified fluvial material (Fluvial material A). A pedon illustrating Orthic Eutric Brunisols of MQ1 is described in Table 256. This pedon was sampled in Bow Pass in Banff. The buried horizons in this pedon are evidence of historic episodic flooding.

Vegetation

The MQ1 Ecosite is characterized by the Engelmann spruce-subalpine fir/grouseberry (C15) and Engelmann spruce-subalpine fir/heather (O10) v.t.s. The C15 v.t. is most abundant but some tracts are dominated by the O10 v.t. Minor amounts of the Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) and Engelmann spruce/hairy wild rye (C33) v.t.s occur on tracts in eastern Banff

Table 255 General features of the Mosquito 1 (MQ1) Ecosite.

Ecosite	Landform	Soils	Vegetation
MQ1	Fluvial material A,B; fan, apron	Brunisolic, Regosolic	Engelmann spruce-subalpine fir open and closed forests

Table 256 Pedon (Alberta 1977 No. 159) description of an Orthic Eutric Brunisol of the MQ1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: MQ1.

LOCATION: MILITARY GRID REF. 11 UNH 3590 2680: NTS MAP AREA 82N 9W.

CLIMATE: 2030 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=PA7104*VTN=C15*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<15% CLAY) AND STRATIFIED (MINERAL), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), FLUVIAL; LANDFORM CLASSIFICATION: FLUVIAL AND UNCONSOLIDATED, FAH; SLOPE: 12% SIMPLE SLOPE OF CLASS 5 (10-15%), FACING SOUTHWEST, SITE AT MIDDLE POSITION, SLIGHTLY ROUNDED MICROTOPOGRAPHY, 500 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, RAPIDLY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; MOD ROCKY.

SPECIAL NOTES: SSM=GT7E47*APN=443-804*LUP=1S=BSC=HOR=PCF=1GR(2)1GR,1CB(3)SGR3CB(4)GR,2CB(6)1GR(6)SGR,2CB(10)=LFH=FF=

LF: 5 TO 0 CM, RANGE 3 TO 7 CM; ABUNDANT, FINE AND MEDIUM ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 1 CM, RANGE 0 TO 3 CM; MATRIX MOIST 10YR 7/2; LOAM; VERY WEAK, MEDIUM, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MICRO ROOTS; GRAVELLY COARSE FRAGMENTS; BROKEN, ABRUPT HORIZON BOUNDARY.

BM: 1 TO 14 CM, RANGE 9 TO 17 CM; MATRIX MOIST 7.5YR 5/4, MATRIX MOIST 5YR 5/6; SILT LOAM; MODERATE, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MICRO ROOTS; COMMON, VERY FINE PORES; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

CK: 14 TO 59 CM, RANGE 38 TO 55 CM; MATRIX MOIST 10YR 3/3; GRAVELLY LOAMY SAND AND SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; LOOSE CONSISTENCE; FEW, FINE ROOTS; FEW, FINE PORES; WEAK EFFERVESCENCE; MODERATELY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS; IRREGULAR, ABRUPT HORIZON BOUNDARY.

LFB1: 59 TO 60 CM, RANGE 0 TO 1 CM; MATRIX MOIST 7.5YR 2/0; FEW, FINE ROOTS; IRREGULAR, ABRUPT HORIZON BOUNDARY.

CKB1: 60 TO 89 CM, RANGE 20 TO 42 CM; MATRIX MOIST 10YR 4/3; VERY GRAVELLY LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; FEW, VERY FINE PORES; WEAK EFFERVESCENCE; STRONGLY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

LFB2: 89 TO 90 CM, RANGE 0 TO 1 CM; MATRIX MOIST 7.5YR 3/2; BROKEN, ABRUPT HORIZON BOUNDARY.

BMB1: 90 TO 98 CM, RANGE 8 TO 17 CM; MATRIX MOIST 10YR 5/4; LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; COMMON, FINE PORES; GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

LFB3: 98 TO 99 CM, RANGE 0 TO 1 CM; MATRIX MOIST 10YR 2/1; BROKEN, ABRUPT HORIZON BOUNDARY.

BMB2: 99 TO 120 CM; MATRIX MOIST 10YR 5/4; GRAVELLY LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE PORES; GRAVELLY AND COBBLY COARSE FRAGMENTS.

HORIZON	PH 1	ORG C (%)	CALC (CARB EQU.%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.2	42.70							
AE									
BM	5.0	2.10		19.1		8.7	4.7	<.1	0.2
CK	7.2	2.00	11.4						
LFB1									
CKB1	7.2	0.30	19.9						
LFB2									
BMB1	6.8	1.30	1.8						
LFB3									
BMB2	6.9	1.20	9.2						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	0.4		0.1	
CK				
LFB1				
CKB1				
LFB2				
BMB1				
LFB3				
BMB2				

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 75- 50 MU SILT	50- 2U SILT	2U CLAY	0.2U CLAY
LF														
AE														
BM										34		49	17	5
CK										74		22	4	1
LFB1														
CKB1										75		21	4	0
LFB2														
BMB1		99	95	84	84					33		47	20	3
LFB3														
BMB2		99	89	86	21					82		38	13	8

and Jasper. The Engelmann spruce-subalpine fir/rock willow/alpine bearberry (O12), Engelmann spruce-subalpine fir/valerian-fleabane (O9), and willow-dwarf birch/fleabane (S4) v.t.s occur in small amounts on tracts that are modified by snow avalanching (MQ1A). A plot illustrating the C15 v.t. of MQ1 is described in Table 257, and represents the vegetation at the pedon sample site described in Table 256.

Discussion

The MQ1 Ecosite is the Upper Subalpine counterpart of the Lower Subalpine Altrude 2 (AL2) and Verdant 1 (VD1) Ecosites.

Table 257 Stand (PA7186) illustrating the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. of the MQ1 Ecosite.

TREE LAYER	
Abies lasiocarpa	20
Picea engelmannii	35
TALL SHRUB LAYER	
Abies lasiocarpa	05
Picea engelmannii	.5
SHRUB LAYER	
Abies lasiocarpa	10
Picea engelmannii	.5
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	01
Achillea millefolium	.5
Anemone parviflora	.5
Antennaria racemosa	01
Arnica cordifolia	.5
Epilobium angustifolium	.5
Erigeron peregrinus	01
Fragaria virginiana	01
Pedicularis bracteosa	03
Potentilla diversifolia	.5
Thalictrum occidentale	05
Vaccinium scoparium	45
Equisetum scirpoides	.5
BRYOID LAYER	
Barbilophozia lycopodioides	45
Brachythecium spp.	05
Cetraria islandica	05
Cladonia ecmocyna	15
Dicranum scoparium	25
Peltigera aphthosa	.5
Pleurozium schreberi	03
EPIPHYTES	
Alectoria sarmentosa	.5
Hypogymnia physodes	.5
Letharia vulpina	.5
Usnea spp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

NG - NIGEL ECOSECTION

The Nigel Ecosection occurs on calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) in the Upper Subalpine portion of the Subalpine Ecoregion. Soils are Eutric Brunisols, and vegetation is moist Engelmann spruce-subalpine fir closed and open forest.

Only two tracts of NG are mapped, both in Banff. One straddles the confluence of Nigel and Hilda Creeks below Sunwapta Pass and the other is on the headwaters of the Red Deer River just below Red Deer Lakes.

Nigel is a valley floor Ecosection. Only one Ecosite is recognized (NG1) with characteristics as outlined in Table 258 and Fig. 45.

NG1 - NIGEL 1 ECOSITE

Ecosite Concept

The NG1 Ecosite is characterized by terraces of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) in the Upper Subalpine portion of the Subalpine Ecoregion. The presence of altered, medium textured eolian material (Eolian material B) and good drainage results in development of Eluviated Eutric Brunisols. Engelmann spruce-subalpine fir/grouseberry (C15) forests and Engelmann spruce-subalpine fir/heather (O10) open forests are the typical vegetation types.

Geomorphology

The NG1 landform is simple, consisting of terraces of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) deposited during deglaciation. These areas have since remained quite stable and have accumulated a thin mantle of altered, medium textured eolian material (Eolian material B). Both mapped areas are bisected by modern (nonglacial) streams that follow the original glaciofluvial stream channels.

Soils

Long-term landform stability has resulted in Eluviated Eutric Brunisols of uniform development on NG1. A pedon illustrative of these soils is shown in Table 259 and Color Plate 45.

Textures of this pedon are finer than modal for glaciofluvial materials because fissile calcareous shales exert a substantial influence in this tract. Massive bedding and coarse fragment content suggest a depositional environment similar to other glaciofluvial deposits in the parks. Horizon development is typical of stable forested areas on calcareous material throughout Banff and Jasper, including the textural Btj horizon immediately below the eolian-glaciofluvial parent material disconformity.

Drainage on NG1 is consistently good because of rapidly permeable coarse materials and terraced surfaces elevated above the local water table.

Table 258 General features of the Nigel 1 (NG1) Ecosite.

Ecosite	Landform	Soils	Vegetation
NG1	Glaciofluvial material B; terrace	Eutric Brunisol	Engelmann spruce-subalpine fir closed and open forests

Table 259 Pedon (Alberta 1979 No. 86) description of an Eluviated Eutric Brunisol of the NG1 Ecosite.

CLASSIFICATION: CANADIAN SYSTEM OF SOIL CLASSIFICATION, 3RD EDITION, 1978. SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: NG1.

LOCATION: MILITARY GRID REF. 11 UNK 6000 1000; NTS MAP AREA 82N 9E.

CLIMATE: 2000 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 4 DEGREES C AT 50 CM IN AUGUST.

VEGETATION: VMm,D9S7P4V7Sm<15%.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), GLACIOFLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: GLACIO FLUVIAL, TERRACED; SLOPE: IX COMPLEX SLOPE OF CLASS 4 (6-9%), FACING EAST, SITE AT MIDDLE POSITION, SLIGHTLY ROUNDED MICROTOPOGRAPHY,200 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, SLOW SURFACE RUNOFF, SEEPAGE ABSENT; SLIGHTLY STONY; BEDROCKY.

SPECIAL NOTES: SSM=UT7143+4PM=010-214+PLM=10+PCP=100(0-3:10R,1CB(4)3GR,2CB(3),6GR,4CB,3ST(6-7)+LFM=EV/FGT=TEXTURES AFFECTED BY ARGILLACEOUS LIMESTONE LITHOLOGY OF SOME OF PARENT MATERIAL=DATE=AUG.26,1979=

LF: 4 TO 0 CM, RANGE 3 TO 5 CM; HORIZON MOIST; MATRIX MOIST 5YR 3/2.5; PLENTIFUL, FINE AND MEDIUM AND COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AE: 0 TO 4 CM, RANGE 3 TO 8 CM; HORIZON MOIST; MATRIX MOIST 10YR 6.5/2; SILT LOAM; MODERATE, MEDIUM, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MEDIUM AND COARSE, HORIZONTAL ROOTS; MODERATELY POROUS, COMMON, HORIZONTAL, EXPED PORES; WAVY, CLEAR HORIZON BOUNDARY.

BM: 4 TO 9 CM, RANGE 4 TO 8 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6, MATRIX MOIST 7.5YR 5/8; SILT LOAM; VERY WEAK, FINE, PLATY STRUCTURE; VERY WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE AND MEDIUM AND COARSE ROOTS; MODERATELY POROUS, FEW, HORIZONTAL, IMPED AND EXPED PORES; WAVY, CLEAR HORIZON BOUNDARY.

2AE: 9 TO 14 CM, RANGE 4 TO 6 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/4; SILT LOAM; WEAK TO MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, MICRO AND VERY FINE ROOTS; MODERATELY POROUS, MANY, RANDOM, IMPED AND EXPED PORES; WAVY, CLEAR HORIZON BOUNDARY.

2BTJ: 14 TO 26 CM, RANGE 10 TO 14 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5.5/6, MATRIX MOIST 10YR 5.5/6; LOAM; MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FIRM CONSISTENCE; VERY FEW, MICRO ROOTS; MODERATELY POROUS, COMMON, RANDOM, EXPED PORES; FEW, VERY THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; WAVY, GRADUAL HORIZON BOUNDARY.

2BCK: 26 TO 38 CM, RANGE 9 TO 14 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/3; GRAVELLY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, MICRO ROOTS; MODERATELY POROUS, FEW, RANDOM, EXPED PORES; WEAK EFFERVESCENCE; STRONGLY CALCAREOUS; WAVY, GRADUAL HORIZON BOUNDARY.

2CK: 38 TO 90 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/3; GRAVELLY COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, MICRO ROOTS; HIGHLY POROUS, MANY, RANDOM, EXPED PORES; VERY WEAK EFFERVESCENCE; VERY STRONGLY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1:1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARGE	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	6.0	42.40							
AE	6.6	3.80		19.3		8.4	0.5	0.1	0.2
BM	8.2	3.40		25.6		8.8	0.4	0.1	0.1
2AE	8.7	0.80		16.8		10.1	0.1	0.1	0.1
2BTJ	6.8		7.3						
2BCK	7.2		23.5						
2CK	7.8		30.6						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	0.2		0.3	
2AE				
2BTJ				
2BCK				
2CK				

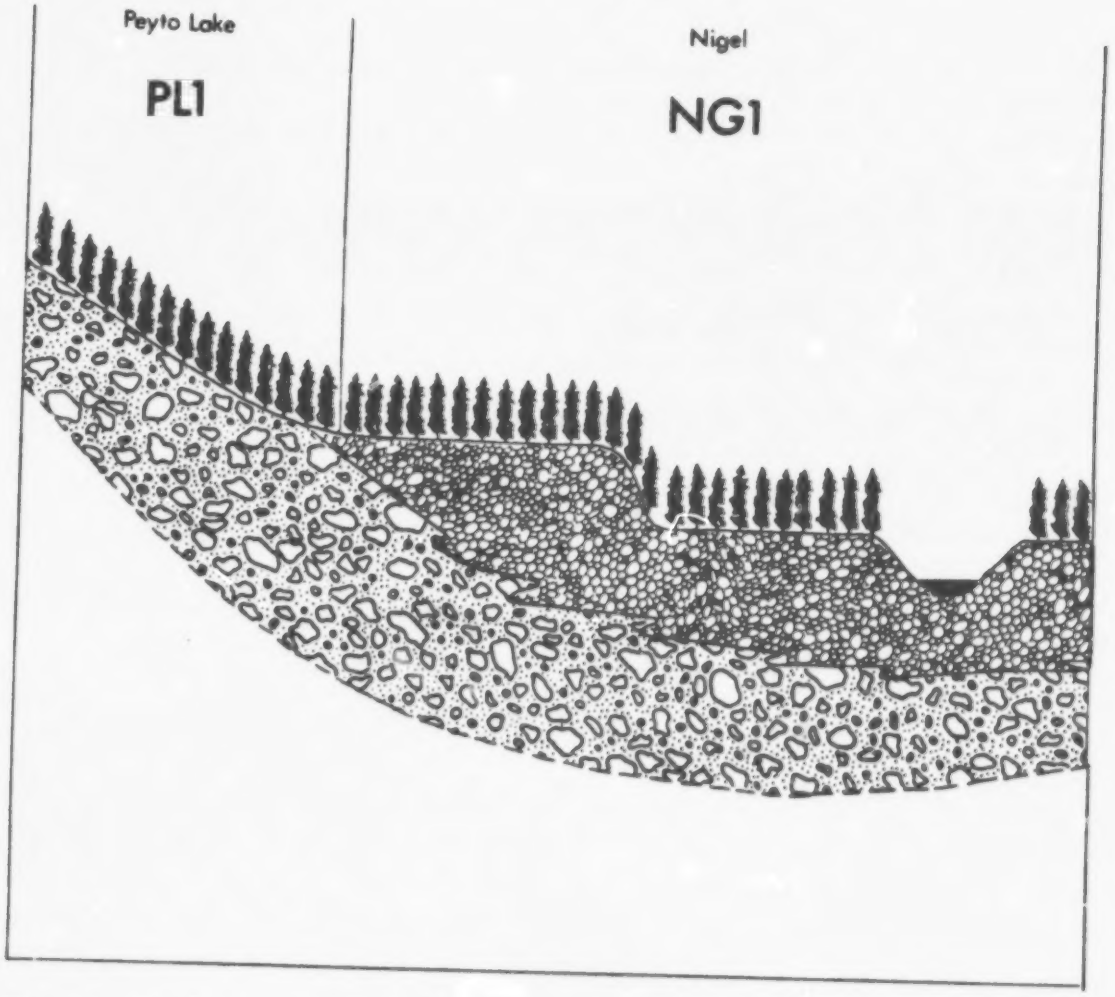
PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 78-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE					1	1	31	6	11	28		70	10	
BM					1	6	40	6	13	28		63	9	
2AE					5	9	46	8	6	31		82	17	
2BTJ					11	12	17	7	6	43		31	26	
2BCK					8	6	17	16	15	49		33	18	
2CK	99	68	38	22	17	18	17	9	9	57		32	11	

PHYSICAL DATA

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AE								
BM								
2AE								
2BTJ								
2BCK								
2CK	21.0	38.0		20.0	1.6		24	02

Figure 45 Landscape schematic of the Nigell (NG1) Ecosite.



The only disturbance to soils is infrequent windthrow of trees causing local examples of the turbic phase.

Vegetation

General stability is reflected in the development of uniform Engelmann spruce-subalpine fir/grouseberry (C15) and Engelmann spruce-subalpine fir/heather (O10) v.t.s on NG1. The tract near Red Deer Lakes is consistently C15 as illustrated in Table 260 and shown in Plate 17. This plot was recorded at the same site as the NG1 pedon sample in Table 259.

Near Sunwapta Pass on Nigel Creek NG1 vegetation is best represented by the O10 v.t., but the similar Engelmann spruce-subalpine fir/heather/feathermoss (C34) v.t. also occurs. This tract in the vicinity of the Columbia Icefield is subject to deep snow accumulation and cold air drainage.

Discussion

The two mapped tracts of NG1 are the only known occurrences of landscape with NG1 characteristics. Glaciofluvial deposits are rare at Upper Subalpine elevations, but in both instances an appropriately gentle valley gradient existed in conjunction with a sufficiently large icefield up valley to generate this landform.

Slopes of both tracts are 1 to 15% and complex. While a majority of the land is nearly level, slopes are called complex because of the short steep terrace scarps (Fig. 45).

The Red Deer River tract of NG1 is uniform and undisturbed, while the Nigel Creek one is more heterogeneous and includes both natural and human disturbance. The north end of the latter tract has a small creek depositing a fan of modern fluvial material

Table 260 Stand (JD9077) illustrating the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. of the NG1 Ecosite.

TREE LAYER	
Abies lasiocarpa	02
Picea engelmannii	30
TALL SHRUB LAYER	
Abies lasiocarpa	10
Picea engelmannii	03
SHRUB LAYER	
Abies lasiocarpa	20
Picea engelmannii	05
Salix glauca	.5
HERB-DWARF SHRUB LAYER	
Achillea millefolium	.5
Antennaria racemosa	01
Arenaria capillaris	.5
Arnica cordifolia	04
Carex phaeocephala	01
Cassiope tetragona	.5
Elymus innovatus	05
Empetrum nigrum	05
Epilobium angustifolium	.5
Erigeron peregrinus	.5
Fragaria virginiana	02
Luzula wahlenbergii	.5
Pedicularis bracteosa	.5
Phyllodoce glanduliflora	07
Poa nervosa	.5
Senecio lugens	01
Solidago multiradiata	.5
Stenanthium occidentale	.5
Vaccinium scoparium	45
Valeriana sitchensis	.5
Equisetum scirpoides	.5
BRYOID LAYER	
Barbilophozia lycopodioides	05
Cetraria spp.	.5
Cladonia arbuscula	.5
Cladonia bacilliformis	.5
Cladonia cenotea	.5
Cladonia coccifera	.5
Cladonia ecmocyna	25
Cladonia phyllophora	.5
Cladonia pyxidata	.5
Cladonia subulata	.5
Cladonia squamules	05
Dicranum muehlenbeckii	30
Drepanocladus uncinatus	.5
Hylocomium splendens	10
Nephroma expallidum	.5
Peltigera aphthosa	05
Peltigera spp.	.5
Pleurozium schreberi	20
Polytrichum juniperinum	.5
Stereocaulon tomentosum	.5
EPIPHYTES	
Bryoria lanestris	.5
Hypogymnia austerodes	.5
Hypogymnia enteromorpha	.5
Letharia vulpina	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

over the glaciofluvial landform. This fan is locally wet and has small patches of the willow/cinquefoil (S8) v.t. The south end of this tract borders a steep avalanched slope, and the avalanche run-out zone extends onto the more level glaciofluvial valley bottom. This same area of NG1 also presently contains a warden cabin, its access via the former road through Sunwapta Pass, and the first portion of the trail to Nigel Pass.

The NG Ecosection may resemble the Azure (AZ) Ecosection, but AZ glaciofluvial material is noncalcareous, has more acidic soils, and is found in association with other noncalcareous Ecosites in areas where lime is absent in the surrounding bedrock. The glaciofluvial NG Ecosection resembles Peyto Lake 1 but the till landform and geologic materials of PL1 separate them as shown in Fig 45.

NH - NASHAN ECOSECTION

The Nashan (NH) Ecosection occurs in the Montane Ecoregion and is characterized by blankets of calcareous, fine textured glaciolacustrine material overlying hummocky and undulating slopes of calcareous glacial materials. The NH Ecosection represents a wet and dry landscape pattern. Wet depressional areas comprise about 80% of the landscape and are dominated by Gleysolic soils and open spruce forests. The dry segments of the landscape are dominated by Luvisolic and Brunisolic soils and lodgepole pine forests.

The NH Ecosection is mapped only in Jasper. The majority of NH is mapped on valley floor benchlands above the Rocky River between Dromore Creek and the Athabasca River valley, and in the Snake Indian River valley between Shale Banks and Seldom Inn warden cabins.

The NH Ecosection is represented by only one Ecosite (NH1). The general features of this Ecosite are outlined in Table 261. Fig. 46 shows the position of NH1 on the landscape.

NH1 - NASHAN 1 ECOSITE

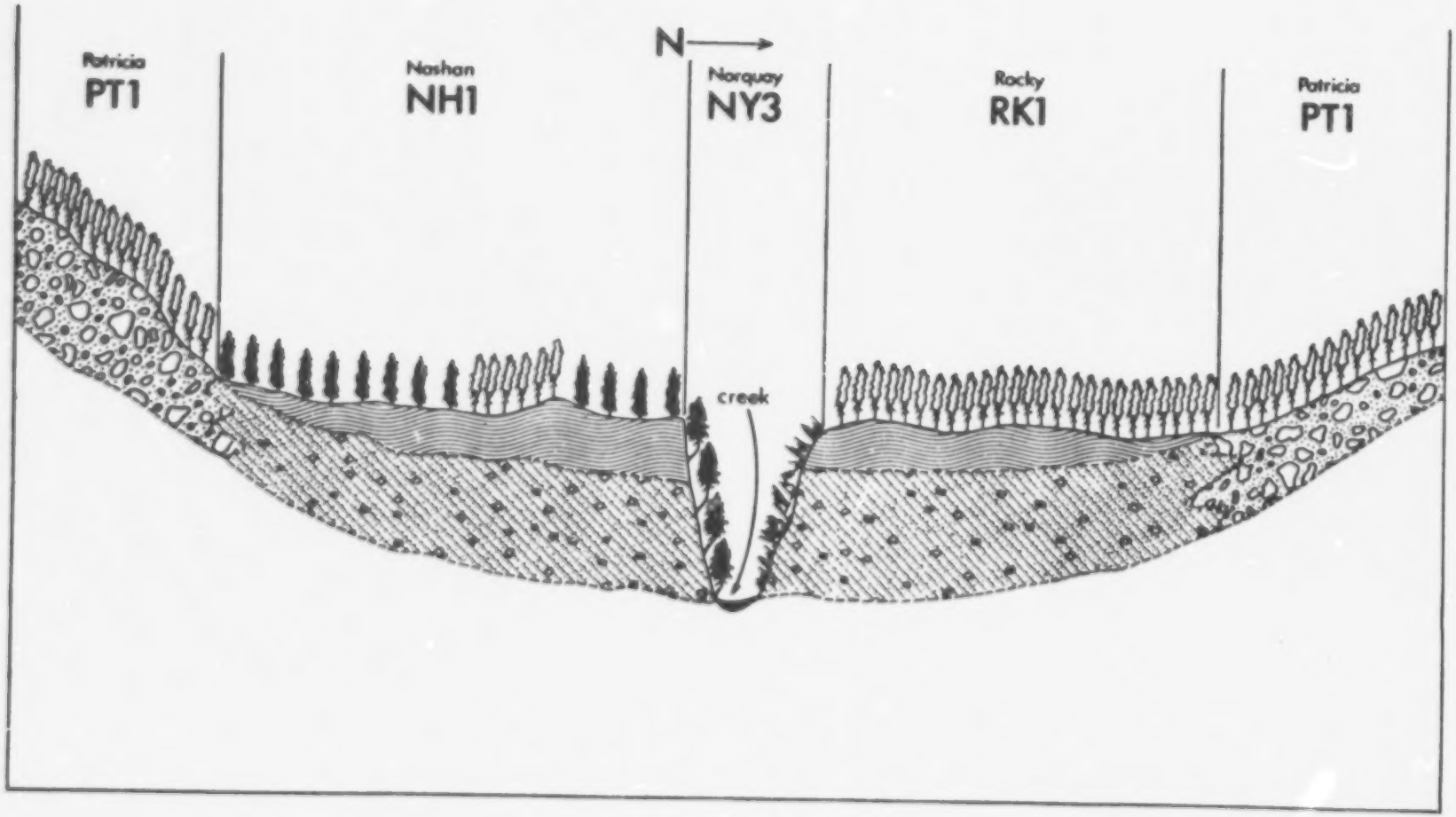
Ecosite Concept

The Montane Ecosite, NH1, represents a wet and dry landscape pattern characterized by blankets of calcareous, fine textured glaciolacustrine material overlying hummocky and un-

Table 261 General features of the Nashan 1 (NH1) Ecosite.

Ecosite	Landform	Soils	Vegetation
NH1	Glaciolacustrine material; blanket	Wet[30]: Gleysolic Dry[30]: Luvisolic, Brunisolic	Wet[30]: spruce open forest Dry[30]: lodgepole pine forest

Figure 46 Landscape schematic showing the relationship of the Nashan 1 (NH1) Ecosite to other Ecosites.



dulating slopes of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). The wetland portion of NH1 dominates about 80% of the landscape and is typified by Orthic and Rego Gleysols associated with the spruce/Labrador tea/brown moss (O11) v.t. On the dry portions of NH1, well to moderately well drained Orthic and Brunisolic Gray Luvisols are more common than Eluviated Eutric Brunisols as the dominant soils and are associated with the lodgepole pine/buffaloberry/twinflower (C19) and lodgepole pine/Labrador tea (C29) v.t.s.

Geomorphology

The NH1 Ecosite is characterized by a wet and dry landscape comprised of blankets of calcareous, fine textured glaciolacustrine material overlying hummocky and undulating slopes of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). The glaciolacustrine material in the lower Rocky and Snake Indian River valleys is sediment deposited in proglacial lakes but the cause of damming is unknown. The dominant wet landscape of NH1 usually has thin organic veneers of fen peat and veneers of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A). Seepage and other surface waters accumulate on the landscape. Slow perviousness of the glaciolacustrine material and slow runoff on the gentle slopes results in poorly drained soils and high, possibly perched, water tables. Slopes are commonly complex and range between 0 and 10%. Thin, discontinuous surficial veneers of altered, medium textured eolian material (Eolian material B) can be identified on the dry segments.

Soils

Soils of the NH1 Ecosite are distributed in a pattern governed by drainage conditions. A set of pedogenically related soils occur on the poorly drained segment. They are best represented by Orthic and Rego Gleysols. Many pedons have organic veneers, usually of moderately decomposed fen peat between 15 and 40 cm thick (peaty phase), overlying mineral soil. Terric Mesisols are accessory soils occuring where fen peat is >40cm thick. Other Organic soils with subdominant humic and fibric layers occur. A pedon illustrating Rego Gleysols (peaty phase) on wetland portions of NH1 is described in Table 262 and shown in Color Plate 46.

Orthic and Brunisolic Gray Luvisols are more common than Eluviated Eutric Brunisols as the dominant soils on the dry (well to moderately well drained) segments of NH1. These soils have textural B horizons, many with pedogenic clay film development sufficient to be Bt horizons, occurring at or below the interface between the eolian and glaciolacustrine material. Iron, aluminum, and humus enriched Bm horizons developed in veneers of altered, medium textured eolian material (Eolian material B) veneers overlie the textural B horizons. Orthic Gray Luvisols occur where the veneer is thin or absent. Orthic Eutric Brunisols are accessory soils that occur where the eluvial (Ae) horizons are weakly expressed or absent. A pedon sampled on the dryland portion of NH1 is described in Table 263 and shown in Color Plate 47.

Vegetation

The NH1 Ecosite is dominated by the spruce/Labrador tea/brown moss (O11) v.t. on wet portions of the landscape and, on the dry segments, with the lodgepole pine/buffaloberry/twinflower (C19) and lodgepole pine/Labrador tea (C29) v.t.s. Black spruce-lodgepole pine/willow/sedge (C8) occurs as an accessory v.t. on the wetland portion of the landscape. On tracts of NH1 mapped in the lower Rocky River area *Larix laricina* (tamarack) is commonly found in the O11 and C8 v.t.s. On dry portions of NH1 the lodgepole pine/feathermoss (C11) v.t. may occur.

A stand illustrating the O11 v.t. on the wet portion of NH1 is described in Table 264 and shown in Plate 43. This stand represents the vegetation at the pedon site described in Table 261. The cover of *Carex aquatilis* at this site is higher than in most O11 stands. A stand illustrating the C19 v.t. on dry upland portions of NH1 is described in Table 321 for the RK1 Ecosite.

Discussion

Dry segments of the NH1 Ecosite have the same characteristics as the Rocky 1 (RK1) Ecosite. However, RK1 is only mapped when dry segments are large enough to be delineated at a map scale of 1:50,000. Tracts of RK1 sometimes occur adjacent to those of NH1 on the landscape. Also, NH1 also resembles the Merlin Castle 1 (MC1) Ecosite but the latter occurs in the Lower Subalpine portion of the Subalpine Ecoregion.

A good example of NH1 occurs on a benchland south of Rocky River between Nashan Creek and the Athabasca River valley.

NT - NUM-TI-JAH ECOSECTION

The Num-Ti-Jah Ecosection is complex and encompasses wet fluvial and fluviolacustrine landforms throughout the Upper Subalpine portion of the Subalpine Ecoregion in Banff and Jasper. Gentle slopes on level plains, aprons, and fans are characteristic. These landforms consist of calcareous, coarse, stratified fluvial material (Fluvial material B),

Table 262 Pedon (Alberta 1979 No. 28) description of a Rego Gleysol from wet segments of the NH1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: REGO GLEYSOL. SOIL MAP UNIT: NOTATION: NH1.

LOCATION: MILITARY GRID REF. 11 UMJ 4140 7908; NTS MAP AREA 83F 4W.

CLIMATE: 1270 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 0 DEG(C) AT 50 CM IN JUNE.

VEGETATION: VRN=JD9021=VTN=011=.

SOIL SITE: PARENT MATERIAL 1: A430; PARENT MATERIAL 2: COARSE LOAMY AND COARSE SILTY (<10% CLAY), WEAKLY CALCAREOUS (1 TO 6% CACO3), FLUVIOLACUSTRINE, UNDIFFERENTIATED OR UNDETERMINED AND ASH; PARENT MATERIAL 3: WEAK CHEMICAL WEATHERING, CLAYEY (>35% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), GLACIOLACUSTRINE, UNDIFFERENTIATED OR UNDETERMINED; LANDFORM CLASSIFICATION: GLACIO LACUSTRINE, CLAYEY, UNDULATING; SLOPE: 0.5% SLOPE OF CLASS 2 (0.5-2%), FACING EAST, SITE AT MIDDLE POSITION, STRONGLY MOUNDED MICROTOPOGRAPHY,; SOIL MOISTURE AND DRAINAGE: POORLY DRAINED, SLOWLY PERVIOUS, SLOW SURFACE RUNOFF, 0.1 M TO WATERTABLE; NONSTONY; NONROCKY.

SPECIAL NOTES: SBN=SC9001=APN=01S-149=PCF=26B(6)=FROZEN LAYER 20-30CM=LFH=NS/EV/LSU=DATE=JUNE 19,1979=

OH: 33 TO 23 CM, RANGE 5 TO 20 CM; MATRIX MOIST 10YR 2/2; WAVY, GRADUAL HORIZON BOUNDARY.

OH1: 23 TO 10 CM, RANGE 6 TO 16 CM; MATRIX MOIST 10YR 2/1; WAVY, DIFFUSE HORIZON BOUNDARY.

OH2: 10 TO 0 CM, RANGE 6 TO 12 CM; MATRIX MOIST 10YR 2/1; WAVY, CLEAR HORIZON BOUNDARY.

ACG1: 0 TO 10 CM, RANGE 8 TO 12 CM; MATRIX MOIST 2.5Y 4/2, MATRIX MOIST 2.5Y 3/0; SILT LOAM; COMMON, MEDIUM, PROMINENT, 5YR 5/6 MOTTLES; WEAK TO MODERATE, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; MASSIVE SECONDARY STRUCTURE; NONSTICKY, NONPLASTIC CONSISTENCE; FEW, VERY FINE ROOTS; FEW, VERY FINE PORES; BROKEN, ABRUPT HORIZON BOUNDARY.

ACG2: 10 TO 13 CM, RANGE 1 TO 5 CM; MATRIX MOIST 10YR 5.5/4; SANDY LOAM; COMMON, MEDIUM, PROMINENT, 5YR 5/6 MOTTLES; WEAK TO MODERATE, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; MASSIVE SECONDARY STRUCTURE; NONSTICKY, NONPLASTIC CONSISTENCE; FEW, VERY FINE ROOTS; FEW, VERY FINE PORES; WAVY, ABRUPT HORIZON BOUNDARY.

2CKG1: 13 TO 120 CM; MATRIX MOIST 2.5Y 6/2; SILTY CLAY; MANY, MEDIUM, PROMINENT, 7.5YR 5/8 MOTTLES; MASSIVE STRUCTURE; FIRM CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; FEW, VERY FINE PORES; COMMON, MODERATELY THICK CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY, 5Y 7/1; MODERATE EFFERVESCENCE; EXTREMELY CALCAREOUS; 10% GRAVELLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
OH	6.5	38.70	0.7
OH1	6.3	36.80	
OH2	6.3	30.90	
ACG1	6.8	3.90	1.1
ACG2	6.9	0.10	1.0
2CKG1	7.7	0.90	43.8

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS														
	% PASSING										% OF SAMPLE				
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
OH															
OH1															
OH2															
ACG1										4		73	23		
ACG2										54		37	9		
2CKG1	99	99	97	95						3		53	44		1.90

PHYSICAL DATA

	MOISTURE STATUS (%)					ENGINEERING							
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
OH													
OH1													
OH2													
ACG1		47.5	28.6										
ACG2													
2CKG1		38.3	16.5			22.0	38.0		22.0	1.6		60	18

Table 263 Pedon (Alberta 1979 No. 29) description of a Brunisolic Gray Luvisol from dry upland segments of the NH1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: BRUNISOLIC GRAY LUVISOL. SOIL MAP UNIT: NOTATION: NH1.

LOCATION: MILITARY GRID REF. 11 UNJ 4100 7965; NTS MAP AREA 83F 4H.

CLIMATE: 1270 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 0 DEG(C) AT 50 CM IN JUNE.

VEGETATION: VPH=JD9022*VTN=C6*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN, UNDIFFERENTIATED OR UNDETERMINED; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), GLACIOLACUSTRINE; LANDFORM CLASSIFICATION: GLACIO LACUSTRINE, CLAYEY, UNDULATING; SLOPE: 3% SLOPE OF CLASS 3 (2-5%), FACING SOUTHEAST, SITE AT UPPER SLOPE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,20 M LONG; SOIL MOISTURE AND DRAINAGE: MODERATELY WELL DRAINED, SLOWLY PERVIOUS, MODERATE SURFACE RUNOFF; NONSTONY; NONROCKY.

SPECIAL NOTES: SSM=SC9001*APM=01B-149*FROZEN AT (GCM=DATE=JUNE 19,1979*

LF: 9 TO 0 CM, RANGE 7 TO 11 CM; MATRIX MOIST 5YR 3/2; NAVY, CLEAR HORIZON BOUNDARY.

BM: 0 TO 3 CM, RANGE 1 TO 5 CM; MATRIX MOIST 5YR 4/6, MATRIX MOIST 7.5YR 5/4; SILT AND SILT LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; FEW, VERY FINE PORES; NAVY, ABRUPT HORIZON BOUNDARY.

AE: 3 TO 4 CM, RANGE 0 TO 3 CM; MATRIX MOIST 10YR 6/3; SILT LOAM; WEAK TO MODERATE, FINE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; COMMON, VERY FINE PORES; BROKEN, CLEAR HORIZON BOUNDARY.

2BT: 4 TO 13 CM, RANGE 1 TO 14 CM; MATRIX MOIST 7.5YR 6/6.4, MATRIX MOIST 10YR 6/4; SILTY CLAY; MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FIRM CONSISTENCE; ABUNDANT, VERY FINE ROOTS; MANY, VERY FINE PORES; COMMON, THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; IRREGULAR, CLEAR HORIZON BOUNDARY.

2CK1: 13 TO 48 CM, RANGE 38 TO 48 CM; EXPED MOIST 10YR 5/3, EXPED DRY 10YR 7/2; SILT; MODERATE TO STRONG, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE PSEUDO; FIRM CONSISTENCE; PLENTIFUL, FINE ROOTS; COMMON, FINE PORES; COMMON, THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; MODERATE EFFERVESCENCE; VERY STRONGLY CALCAREOUS; NAVY, DIFFUSE HORIZON BOUNDARY.

2CK2: 48 TO 65 CM; EXPED MOIST 10YR 5/2, EXPED DRY 10YR 7/2; SILT; MODERATE TO STRONG, MEDIUM, SUBANGULAR BLOCKY STRUCTURE PSEUDO; FIRM CONSISTENCE; FEW, FINE ROOTS; FEW, VERY FINE PORES; FEW, THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; MODERATE EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	6.1	38.00							
BM	6.4	2.20		20.1		18.4	1.3	0.1	0.3
AE									
2BT	6.8	1.20	2.1						
2CK1	7.2		33.8						
2CK2	7.3		45.8						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
BM	0.1		~.1	
AE				
2BT				
2CK1				
2CK2				

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS % PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 78-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF															
BM										5		80	15		1.60
AE															
2BT										5		48	47		
2CK1										2		91	7		
2CK2		99	98	98	97					2		90	8		1.60

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
BM	10.5	41.6											
AE													
2BT	15.8	32.4											
2CK1													
2CK2	16.7	29.2				21.0	32.0		21.0	1.6		60	10

Table 264 Stand (JD9021) illustrating the spruce/ Labrador tea/ brown moss (011) v.t of weg segments of the NH1 Ecosite.

TREE LAYER	
Larix laricina	01
Picea mariana	15
TALL SHRUB LAYER	
Larix laricina	.5
Picea mariana	07
SHRUB LAYER	
Betula glandulosa	.5
Larix laricina	02
Ledum groenlandicum	35
Picea mariana	03
Salix glauca	01
Salix myrtillifolia	10
HERB-DWARF SHRUB LAYER	
Arctostaphylos rubra	10
Carex aquatilis	40
Carex concinna	01
Carex gynocrates	02
Carex vaginata	05
Deschampsia caespitosa	05
Eriophorum brachyantherum	01
Geocaulon lividum	.5
Mitella nuda	01
Petasites palmatus	.5
Pyrola virens	.5
Rosa acicularis	.5
Rubus acaulis	.5
Viburnum edule	.5
Equisetum arvense	05
Equisetum scirpoides	05
BRYOID LAYER	
Aulacomnium palustre	45
Calliergon giganteum	.5
Drepanocladus aduncus	05
Hylocomium splendens	05
Mnium rugicum	.5
Peltigera aphthosa	.5
Tomenthypnum nitens	30
EPIPHYTES	
Alectoria spp.	.5
Lecidella glomerulosa	.5
Parmelia subelegantula	.5
Ramalina sinensis	.5
Usnea cavernosa	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

noncalcareous, coarse, stratified fluvial material (Fluvial material A), altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) and occasionally, calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B). Horizontal fens that thinly mantle the fluvial and fluviolacustrine materials on the wettest localities also occur, particularly on the NT3 Ecosite.

Gleysolic soils lacking pedogenic horizonation characterize the NT Ecosection. Organic soils are also common on the NT3 Ecosite. Shrubby vegetation versus meadow and fen vegetation differentiates the two NT Ecosites. The NT2 Ecosite is dominated by wet and moist shrub thicket, NT3 by wet herb meadow, cottongrass fen and sedge fen. The landform, soil and vegetation differences of the two NT Ecosites are outlined in Table 265.

The NT Ecosection occurs most often on valley and col floors adjacent to streams. High water tables, seepage, and discharge account for its wetness. The NT2 and NT3 Ecosites are shown, schematically, on Figs. 42, 53, and 54. A few tracts occur on broad, gently sloping shoulders and are affected primarily by seepage.

NT2 - NUM-TI-JAH 2 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, NT2, encompasses wet fluvial landforms dominated by shrub vegetation. These landforms consist primarily of calcareous, coarse, stratified fluvial material (Fluvial material B) and noncalcareous, coarse, stratified fluvial material (Fluvial material A). Surface expressions include level floodplains, aprons, and fans. Many surfaces are eroded (channeled).

Imperfectly to poorly drained Rego Gleysols, most with surface peat layers, dominate NT2. These reflect recent parent material deposition, prolonged periods of saturation, and organic material accumulation in stable geomorphic environments. Vegetation is dominated by the willow/cinquefoil (S8), willow-dwarf birch/fleabane (S4), and willow/ timber oatgrass (S11) v.t.s. Of these three, S8 is most abundant.

Geomorphology

The NT2 Ecosite is typified by fluvial landforms consisting of noncalcareous, coarse, stratified fluvial material (Fluvial material A) and calcareous, coarse, stratified fluvial material (Fluvial material B). Weakly calcare-

Table 265 General features of the Num-Ti-Jah (NT) Ecosites.

Ecosite	Landform	Soils	Vegetation
NT2	Fluvial material A,B; level, apron, fan	Gleysolic	wet shrub thicket, moist shrub thicket
NT3	Fluviolacustrine material A,B; level and horizontal fen	Gleysolic, Organic	wet herb meadow, cottongrass fen, sedge fen

ous intergrades between the two fluvial deposits occur often. Important accessory genetic materials, occurring as veneers on or layers within the fluvial deposits, are calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) and occasionally, altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A). The fluviolacustrine materials occur on what were backwater depositional localities of floodplains and as veneers on the fringes of gently sloping aprons and fans. Organic soils or Gleysolic soils with well developed peat layers are frequently associated with the fluviolacustrine material, both features indicating ponding by currentless, relatively stagnant water. The fluvial and fluviolacustrine deposits may contain reworked material originally deposited as altered, medium textured eolian material (Eolian material B). Glaciofluvial deposits, mainly calcareous, coarse textured glaciofluvial material (Glaciofluvial material B), occur on tracts associated with glacial streams (e.g. Douglas Creek). Various tills underlie the fluvial deposits at shallow depths on some localities. Small morainal outcrops occur sporadically.

Surfaces of NT2 Ecosite soils are usually thinly mantled by peat derived primarily from sedges and brown mosses (e.g. *Tomenthypnum nitens* and *Aulacomnium palustre*). This fen peat is dominantly moderately decomposed. The accessory landforms include horizontal fens occurring on ponded localities where organic layers exceed 40 cm in thickness.

Topographically, NT2 displays gentle linear slopes on level floodplains, aprons, and fans. Fluvial blankets overlying till also occur occasionally. Slopes commonly range from 0 to 15% with slopes over 5% encompassing fans and aprons extending from lower valley walls to valley floors. Tracts with complex slopes have irregular surfaces reflecting, in part, underlying morainal landforms. Slope continuity is often broken by abandoned and active stream channels including their natural levee borders (Eroded modifier, C.S.S.C. 1978b). These are most abundant on floodplains. Weakly expressed terracing (risers <1 m) is a minor feature on some floodplain tracts.

Soils

Imperfectly to poorly drained Rego Gleysols dominate the NT2 Ecosite. Prolonged periods of saturation (high water tables or seepage) plus recent sediment deposition have inhibited pedogenic development other than gleization. Thin peat layers occur at the surface on most NT2 soils. Terric Mesisols occur as accessory soils where organic accumulations exceed 40 cm on very poorly drained, ponded sites. These Organic soils are most often associated with minor amounts of v.t.s such as water sedge-beaked sedge (H11) and only occasionally with the dominant shrub types, namely willow/cinquefoil (S8). Gleyed Cumulic Regosols also occur as accessory soils and are associated with imperfectly drained, slightly elevated sites where the upper portions of control sections are weakly gleyed. Organic soils with subdominant humic or fibric layers, Humic Gleysols, Orthic Gleysols, gleyed Brunisolic soils, and gleyed Regosolic soils other than Gleyed Cumulic Regosols occur in minor amounts on wet sites. Well to moderately well drained Brunisolic and Regosolic soils occur sporadically on sites where the fluctuating water table rarely reaches the control section. Soils with disrupted layers occur occasionally, these being affected primarily by cryoturbation.

A pedon illustrating Rego Gleysols of NT2 is described in Table 266. The sample site is shown in Plate 140. This pedon varies slightly from modal NT2 soils. Its lack of surface peat layers reflects the relatively dry surface conditions of the site. It also has an abnormally thick fluviolacustrine veneer.

Vegetation

Vegetation of the NT2 Ecosite is complex and is best represented by the willow/cinquefoil (S8), willow-dwarf birch/fleabane (S4), and willow/timber oatgrass (S11) v.t.s. While S8 is most abundant, some tracts may be dominated by S4 and S11. On NT2, S4 and S11 display a wide range of moisture tolerances, occurring throughout well drained to poorly drained sites. They tend to occur mostly on dry surfaces even though the water table may be near the surface for part of the growing season. Dwarf birch-shrubby cinquefoil-willow/brown moss (S1), water sedge-beaked sedge (H11), and fleabane-valerian (H16) are accessory v.t.s. Occasionally S1 occurs at low to moderate Upper Subalpine elevations, and H11 occurs on ponded localities. H16 is possibly related to high snow accumulation localities. Cottongrass/moss (H10) also occurs in minor amounts on ponded localities, but less frequently than H11. Patches of Engelmann spruce-subalpine fir/valerian-fleabane (O9) v.t. and Engelmann spruce-subalpine fir/rock willow/alpine bearberry (O12) v.t. occur in small amounts. Other v.t.s occurring in minor amounts are mountain marigold-globeflower (H9), arctic willow-cinquefoil (L7), dwarf birch-willow/kobresia (S9), and willow/hairy wild rye (S12). The S9 and S12 v.t.s. favor dry surface conditions and occupy portions of tracts that are transitional to the Cyclone 1 (CN1) Ecosite. Actively aggrading and eroding stream reaches lacking vegetation occupy up to 50% of some tracts. Tracts mapped as NT2+SC (e.g. Douglas Creek in Banff) have 50 to 80% unvegetated portions. Modification of NT2 vegetation by avalanching (NT2A) occurs infrequently.

Table 266 Pedon (Alberta 1979 No. 77) describing a Rego Gleysol of the NT2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: REGO GLEYSOL. SOIL MAP UNIT: NOTATION: NT2.

LOCATION: MILITARY GRID REF. 11 UPH 9340 8660; NTS MAP AREA 83C 3#.

CLIMATE: 2830 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 6 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JE9179#VTH=S1?#..

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY) AND STRATIFIED (MINERAL AND ORGANIC), WEAKLY CALCAREOUS (1 TO CACO3), FLUVIOLACUSTRINE; PARENT MATERIAL 2: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND STRATIFIED (MINERAL), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), FLUVIAL; LANDFORM CLASSIFICATION: FLUVIAL, ERODED(CHANNELLED), LEVEL; SLOPE: 2% COMPLEX SLOPE OF CLASS 3 (2-5%), FACING SOUTH, SITE AT MIDDLE POSITION, MODERATELY MOUNDED MICROTOFOGRAPHY,200 M LONG; SOIL MOISTURE AND DRAINAGE: POORLY DRAINED, MODERATELY PERVIOUS, SLOW SURFACE RUNOFF, SEEPAGE PRESENT, 0.7 M TO APPARENT WATERTABLE; NONSTONY; NONROCKY.

SPECIAL NOTES: SSN=BN9130#APN=A23010-196#RLU=15#MLU=F2+F3#PCF=SGR,2CB,1ST(8)#A+B AND AHB HORIZONS ARE CHARCOAL LAYERS#BANDS AND STREAKS OF CHARCOAL IN CKG1 + CKG3 HORIZONS#CKG1 LAYERED HORIZON# AHB-NOT SAMPLED#CKG2,A+B,AND AND BHB ARE ASHY#DATE=SEPT.28, 1979#

ACK: 0 TO 9 CM, RANGE 7 TO 12 CM; MATRIX MOIST 10YR 2/2, MATRIX MOIST 10YR 3/2; SILT LOAM; VERY WEAK, FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE ROOTS; FEW, MICRO PORES; VERY WEAK EFFERVESCENCE; SMOOTH, CLEAR HORIZON BOUNDARY.

CKG1: 9 TO 40 CM, RANGE 23 TO 38 CM; MATRIX MOIST 10YR 3.5/3, MATRIX MOIST 10YR 3/3; SILT LOAM; MANY, FINE, PROMINENT, 5YR 4/4 MOTTLES; VERY WEAK, FINE, GRANULAR STRUCTURE; STRUCTURELESS SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE ROOTS; COMMON, MICRO PORES; MODERATE EFFERVESCENCE; WAVY, ABRUPT HORIZON BOUNDARY.

CKG2: 40 TO 44 CM, RANGE 0 TO 8 CM; MATRIX MOIST 10YR 4/3, MATPIX MOIST 10YR 6/3; SILT LOAM; FEW, FINE, PROMINENT, 7.5YR 4/6 MOTTLES; STRUCTURELESS STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, MICRO AND VERY FINE ROOTS; FEW, MICRO PORES; MODERATE EFFERVESCENCE; BROKEN, ABRUPT HORIZON BOUNDARY.

A+B: 44 TO 51 CM, RANGE 0 TO 13 CM; MATRIX MOIST 10YR 2/1, MATRIX MOIST 5YR 3/3; SILT LOAM; STRUCTURELESS STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, MICRO AND VERY FINE ROOTS; COMMON, MICRO PORES; VERY WEAK EFFERVESCENCE; BROKEN, ABRUPT HORIZON BOUNDARY.

CKG3: 51 TO 63 CM, RANGE 10 TO 16 CM; MATRIX MOIST 10YR 3.5/3; SILT LOAM; COMMON, FINE, DISTINCT, 10YR 4/6 MOTTLES; STRUCTURELESS STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, MICRO ROOTS; MANY, MICRO PORES; MODERATE EFFERVESCENCE; WAVY, ABRUPT HORIZON BOUNDARY.

AHB: 63 TO 64 CM, RANGE 0 TO 3 CM; MATRIX MOIST 10YR 2/1; SILT LOAM; STRUCTURELESS STRUCTURE; NONSTICKY, NONPLASTIC CONSISTENCE; VERY FEW, MICRO ROOTS; MANY, MICRO PORES; MODERATE EFFERVESCENCE; BROKEN, ABRUPT HORIZON BOUNDARY.

BHB: 64 TO 67 CM, RANGE 1 TO 8 CM, MATRIX MOIST 7.5YR 4/6; SILT LOAM; VERY WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; STRUCTURELESS SECONDARY STRUCTURE; NONSTICKY, NONPLASTIC CONSISTENCE; VERY FEW, MICRO ROOTS; MANY, MICRO PORES; WAVY, CLEAR HORIZON BOUNDARY.

CKG4: 67 TO 80 CM; MATRIX MOIST 10YR 4/4; SILT LOAM; STRUCTURELESS STRUCTURE; NONSTICKY, NONPLASTIC CONSISTENCE; MODERATE EFFERVESCENCE; 50% ANGULAR GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
ACK	7.4	1.20	14.2						
CKG1	7.3		15.7						
CKG2	7.2		9.7						
A+B	7.1	10.20	0.7	68.9		48.9	4.8	0.1	0.1
CKG3	7.1		0.3						
AHB									
BHB	7.2	3.00	0.7	28.9		22.1	2.5	0.1	0.1
CKG4	7.5		29.7						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
ACK				
CKG1				
CKG2				
A+B				
CKG3				
AHB				
BHB	0.1		0.1	
CKG4				

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
ACK														
CKG1										17		63	20	
CKG2										17		64	19	
A+b										19		66	15	
CKG3	99	99	99	99						16		65	19	
AHB										12		66	22	
BHB														
CKG4	99	75	46	34						17		78	5	
										32		55	13	

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
ACK								
CKG1								
CKG2								
A+B								
CKG3	37.8	69.8						
AHB							75	12
BHB								
CKG4	24.8	34.8					24	04

A plot illustrating S8 on NT2 is described in Table 267. This plot is located <25 km southeast of the pedon sample site.

Table 267 Stand (IC6021) illustrating the willow-cinquefoil (S8) v.t. of the NT2 Ecosite.

	SHRUB LAYER
Betula glandulosa	05
Salix barclayi	25
Salix barrattiana	45
	HERB-DWARF SHRUB LAYER
Achillea millefolium	05
Anemone drummondii	.5
Antennaria lanata	.5
Carex media	05
Castilleja occidentalis	.5
Erigeron peregrinus	.5
Fragaria virginiana	03
Petasites vitifolius	01
Poa alpina	10
Pyrola asarifolia	.5
Ranunculus eschscholtzii	01
Senecio triangularis	.5
Sibbaldia procumbens	.5
Taraxacum officinale	.5
Thalictrum occidentale	02
Trollius albiflorus	05
Equisetum scirpoides	.5
Equisetum variegatum	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The NT2 Ecosite encompasses wet fluvial terrain dominated by shrubby vegetation in the Upper Subalpine. Vermilion Lakes 5 (VL5) and Hector 4 (HC4) are the Montane and Lower Subalpine counterparts, respectively, of NT2. In particular, HC4 resembles NT2 but has a greater diversity of dominant drainage regimes and vegetation reflecting the Lower Subalpine environment. VL5 has Montane rather than Upper Subalpine vegetation and occurs in active geomorphic environments. In a broad sense, NT2 resembles gently sloping, wet portions of the Alpine Katherine 1 (KA1) Ecosite. However, KA1 occurs mainly on fluvial fans and aprons rather than fluvial and fluviolacustrine landforms and is dominated by meadow and tundra vegetation. The Sphinx 3 (SX3) Ecosite resembles NT2 in terms of vegetation but is characterized by morainal landforms with a greater variety of soils. In terms of landform, NT2 resembles the Cyclone 1 (CN1) Ecosite. However, CN1 has significantly drier soils and vegetation. Wet segments of the Peyto Lake 5 (PL5) and occasionally, Egypt 3 (EG3) Ecosites resemble NT2. These moraine-dominated Ecosites have a compound dry > wet landscape pattern with attendant differences in soil and vegetation. The NT2 Ecosite is differentiated from NT3 by its soils and vegetation (Table 265) reflecting a slightly different geomorphic history.

NT3 - NUM-TI-JAH 3 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, NT3, encompasses ponded, fluviolacustrine, backwater floodplains dominated by meadow and fen vegetation. This landform consists primarily of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A), and occasionally of calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B). Sediment loads of inundating waters are low and promote the accumulation of organic materials. Horizontal fens that thinly mantle the fluviolacustrine deposits occur frequently. The floodplain surfaces are usually eroded (channeled) with slightly elevated, gently sloping levees bordering the channels. Pools, ponds, and small lakes occur sporadically on NT3.

The poorly to very poorly drained soils of NT3 reflect, in their development, the degree of ponding and amount of peat accumulation. Rego Gleysols and Terric Mesisols are dominant with the Rego Gleysols being more abundant. Vegetation of NT3 reflects degree of ponding and elevation and is dominated by the mountain marigold-globeflower (H9), cottongrass/moss (H10), and water sedge-beaked sedge (H11) v.t.s.

The NT3 Ecosite is primarily associated with high snowfall areas that are dominated by Gog Group quartzites and Miette Group slates and shales. Consequently, it is most abundant along the Continental Divide, particularly in northwestern Jasper, north and west of the Athabasca River, Snaring River, and Blue Creek valleys.

Geomorphology

The NT3 Ecosite is typified by level fluviolacustrine floodplains consisting primarily of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A), and less often of calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B). Fluvial deposits, mainly noncalcareous, coarse, stratified fluvial material (Fluvial material A), also occur occasionally at the mineral surface and probably underlie the fluviolacustrine deposits. At undetermined depths, on some tracts, fluviolacustrine deposits are probably underlain by till, mainly noncalcareous, medium textured till (Till B). The fluviolacustrine materials were deposited by siltation from silt-laden glacial meltwaters ponded on backwater floodplains. These floodplains were created by downstream constriction of major drainage channels. The ponded basins also received, from surrounding slopes, slope-wash material deposited along their margins. Although ponding is still extensive on NT3, sediment deposition is minor due to the low

Table 268 Pedon (Alberta 1979 No. 50) describing a Terric Mesisol of the NT3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: TERRIC MESISOL. SOIL MAP UNIT: NOTATION: NT3.

LOCATION: MILITARY GRID REF. 11 ULJ 0230 8055; NTS MAP AREA 83E SW.

CLIMATE: 1000 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 7 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPH=SJ/3134=VTH=H11=..

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, STRATIFIED (MINERAL AND ORGANIC), ORGANIC, AA30; PARENT MATERIAL 2: FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), FLUVIOLACUSTRINE; LANDFORM CLASSIFICATION: FEN, HORIZONTAL; SLOPE: 1% SIMPLE SLOPE OF CLASS 2 (0.5-2%), FACING NORTHWEST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,500 M LONG; SOIL MOISTURE AND DRAINAGE: VERY POORLY DRAINED, MODERATELY PERVIOUS, PONDED SURFACE RUNOFF, SEEPAGE PRESENT, 0.1 M TO APPARENT WATERTABLE; HORSTONY; HUMUS-FORM: MESIC AND MESIC.

SPECIAL NOTES: SSH=SC9079=APH=01S-01S=LFH=HN/FLL=DATE=SEPT.12.1979=LFH=HN/FL=DATE=SEPT.12.1979=

OM1: 0 TO 15 CM, RANGE 4 TO 6 CM; MATRIX MOIST 10YR 2/2; ABUNDANT, MICRO ROOTS; SMOOTH, CLEAR HORIZON BOUNDARY.

OM2: 15 TO 32 CM, RANGE 15 TO 19 CM; MATRIX MOIST 2.5YR 3/2; ABUNDANT, MICRO AND FINE ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

O+C1: 32 TO 37 CM, RANGE 4 TO 6 CM; MATRIX MOIST 5YR 3/2, MATRIX MOIST 5Y 6/1; PLENTIFUL, MICRO ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

OM3: 37 TO 44 CM, RANGE 8 TO 10 CM; MATRIX MOIST 10YR 2/2; PLENTIFUL, MICRO ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

O+C2: 44 TO 50 CM, RANGE 3 TO 5 CM; MATRIX MOIST 5Y 2.5/2, MATRIX MOIST 5Y 5/1; FEW, MICRO ROOTS; SMOOTH, CLEAR HORIZON BOUNDARY.

O+C3: 50 TO 61 CM, RANGE 10 TO 12 CM; MATRIX MOIST 10YR 3/2; CLAY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; STICKY, VERY PLASTIC CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE ROOTS; MANY, VERY FINE PORES; SMOOTH, ABRUPT HORIZON BOUNDARY.

CG: 61 TO 80 CM, RANGE 17 TO 21 CM; MATRIX MOIST 5Y 6/1; SILTY CLAY LOAM; VERY FEW, MICRO ROOTS; SMOOTH, GRADUAL HORIZON BOUNDARY.

O+C4: 80 TO 105 CM; MATRIX MOIST 10YR 2/2, MATRIX MOIST N 5.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
OM1	4.9	39.70						
OM2	5.0	45.00						
O+C1	5.1	24.10						
OM3	5.2	39.60						
O+C2	5.3	24.60						
O+C3	5.3	25.90						
CG	5.4	2.50	9.5		6.0	0.8	0.1	0.1
O+C4	5.4	12.80						

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
OM1								
OM2								
O+C1								
OM3								
O+C2								
O+C3								
CG	27.0	48.0					A4	OH
O+C4								

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 75-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
OM1															0.10
OM2															0.30
O+C1															
OM3															
O+C2															
O+C3															
CG	99	99	99	99						2		67	31		1.80
O+C4															

sediment loads of inundating waters. Recent and present conditions favor organic material accumulation under well developed moss layers. Consequently, most NT3 soils have thin peat layers at the surface. This peat is derived primarily from sedges and brown mosses (e.g. *Tomenthypnum nitens* and *Aulacomnium palustre*) and rarely exceeds 1.2 m in thickness. Moderate decomposition is characteristic but fibric and humic layers also occur. Where the peat is >40 cm thick, the landform is classified as horizontal fen (C.S.S.C. 1978b). Horizontal fens dominate some NT3 tracts (e.g. the valley floor below Grant Pass in Jasper). Mineral and organic layers are occasionally interbedded.

Topographically, NT3 displays gentle linear slopes on level to gently concave or bowl-shaped floodplains. Slopes commonly range from 0 to 3% with steeper gradients marking tract fringes to surrounding, steeper sloping landscape. Slope continuity is broken by numerous abandoned and active stream channels meandering across the landscape (Eroded modifier, C.S.S.C. 1978b). Gently sloping, slightly elevated levees often border the channels. Excepting the levees and tract margins, NT3 is usually inundated for much of the summer season. Pools, ponds, and small lakes occur sporadically on the landscape.

Soils

The NT3 Ecosite is dominated by Rego Gleysols and Terric Mesisols with the Rego Gleysols being most abundant. Some tracts, however, are dominated by Terric Mesisols (e.g. below Grant Pass). These poorly to very poorly drained soils are subjected to prolonged periods of saturation that promote strong gleying but inhibit pedogenic horizonation. Recent and present geomorphic environments favor fen peat accumulation on soil surfaces. Consequently, NT3 soils have variable thicknesses of surface organic horizons composed predominantly of moderately decomposed fen peat. Terric Mesisols occur where peat accumulations exceed 40 cm. Organic soils with subdominant humic or fibric layers may also occur. Other soils occurring in minor amounts are Humic Gleysols, gleyed Brunisolic soils, and gleyed Regosolic soils. Soils with disrupted layers occur sporadically, these being affected primarily by cryoturbation. A pedon illustrating Terric Mesisols of NT3 is described in Table 268 and shown in Color Plate 48.

Vegetation

Vegetation of the NT3 Ecosite is dominated by the mountain marigold-globeflower (H9), cottongrass/moss (H10), and water sedge-beaked sedge (H11) v.t.s. Distribution of these types is related to elevation and degree of ponding. The H9 v.t. occurs in poorly drained, non-ponded localities including tract fringes and elevated levees. Both H10 and H11 are associated with ponding but H10 is more abundant at higher elevations. Willow/cinquefoil (S8) and fleabane-valerian (H16) are important accessory v.t.s occurring on imperfectly to poorly drained levees and tract fringes. A plot representing vegetation of the pedon sample site (Table 268) and illustrating H11 on NT3 is presented in Table 269 and Plate 141. This H11 plot differs from modal by its high shrub content and H10 tendencies.

Table 269 Stand (SJ9134) illustrating the water sedge-beaked sedge (H11) v.t. of the NT3 Ecosite.

SHRUB LAYER	
Salix glauca	18
HERB-DWARF SHRUB LAYER	
Caltha leptosepala	.5
Carex aquatilis	60
Castilleja spp.	.5
Eriophorum scheuchzeri	10
Leptarrhena pyrolifolia	01
Parnassia spp.	.5
BRYOID LAYER	
Aulacomnium palustre	05
Bryum pseudotriquetrum	.5
Paludella squarrosa	10
Riccardia pinguis	.5
Sphagnum warnstorfii	30
Tomenthypnum nitens	35
Calliergon spp.	02

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

The NT3 Ecosite is the least extensive of the NT Ecosites and is of low areal extent. It encompasses wet backwater floodplains dominated by meadow and fen vegetation. The NT3 Ecosite resembles the Vermilion Lakes 1 (VL1) and Hector 2 (HC2) Ecosites which are its Montane and Lower Subalpine counterparts, respectively. However, both VL1 and HC2 occur on calcareous fluviolacustrine floodplains rather than the generally noncalcareous floodplains of NT3. Also, most HC2 and several VL1 tracts are presently experiencing sediment deposition whereas NT3 is geomorphically stable. Soils and vegetation reflect these differing geomorphic environments and the different Ecoregions and subdivisions thereof. In general terms, the Sphinx 1 (SX1) Ecosite sometimes resembles NT3 but is characterized by a broad range of imperfectly to poorly drained soils on morainal rather than fluvial landforms. Vegetation reflects the landform and drainage differences. The NT3 Ecosite is differentiated from NT2 by its soil and vegetation (Table 265) reflecting a slightly different geomorphic history.

NY - NORQUAY ECOSECTION

The Norquay Ecosection is characterized by calcareous, medium textured till (Till C) and calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) in the Montane Ecoregion. Brunisolic and Regosolic soils are found in patterns on the landscape as are lodgepole pine forest, Douglas fir forest, white spruce-Douglas fir forest, open forests of Douglas fir, and low shrub-herb meadows.

This Ecosection is widely distributed throughout the Montane, often bordering rivers and on lower valley wall positions. In Banff, NY ranges from the east gate to Johnston Creek in the Bow River valley, and along the lower North Saskatchewan and Howse Rivers in those locations where eolian material is not actively accumulating over ice contact materials. In Jasper, NY is mapped in the Athabasca River valley and its major tributaries from the east gate to Mount Kerkeslin. This includes the Miette River valley to the west gate, and lower portions of the Fiddle, Rocky, Snake Indian, Snaring, Maligne, and Whirlpool Rivers, and wider creek valleys such as Moosehorn and Jacques.

Two Ecosites (NY1, NY3) are recognized within the NY Ecosection. Table 270 lists the essential characteristics of each Ecosite. A representation of NY Ecosites on the landscape is presented in Fig. 47.

NY1 - NORQUAY 1 ECOSITE

Ecosite Concept

The Norquay 1 Ecosite is characterized by blankets and veneers of calcareous, medium textured till (Till C) over inclined bedrock in the Montane Ecoregion. Orthic Eutric Brunisols form a pattern with less frequently encountered Orthic Regosols on rapidly to well drained slopes, and is forested with either Douglas fir/hairy wild rye (C1) or lodgepole pine/buffaloberry/showy aster (C6) v.t.s. It is found throughout the Montane on steeper (30-70%) grades. The linear inclined form of NY1 landforms is considered depositional (cf NY3, and Fig. 47).

Geomorphology

Modally, NY1 landforms are composed of blankets and veneers, often gullied, of calcareous, medium textured till (Till C) over inclined bedrock. While surfaces may be modified by gully erosion or shallow surface colluviation, especially on south aspects, inclined surficial expression is controlled by the ice depositional medium and the surrounding bedrock. Although NY1 tracts are often in areas where altered, medium textured eolian material (Eolian material B) is abundant, its presence or absence at any given location depends on local surface stability. Small fluvial fans and aprons are common at the base of gullied NY1 slopes. Bedrock also may be exposed where original morainal deposition was thin.

In the Miette River valley in Jasper, NY1 is mapped on areas of noncalcareous, medium textured till (Till B). The absence of lime is controlled by the extensive Miette Group strata in the surrounding area.

Soils

Soils on NY1 are strongly influenced by present and historical local surface stability on the inclined slopes. The landscape pattern is dominated by Orthic Eutric Brunisols with a lesser percentage of Orthic Regosols. Both soils reflect the quasi-equilibrium of the ground surfaces of this Ecosite. Erosion is gradually removing the surface layer at a rate just slower than pedogenic processes are operating to produce horizon differentiation. The Orthic Regosols frequently have Bm horizons, but <5 cm thick, indicating they are similar to the Orthic Eutric Brunisols in genesis. This pattern is more evident on steeper southerly aspects where exposure, through mechanisms such as greater frequency of fire and less vegetation cover, results in bare mineral soil that is subject to erosion. Northerly aspects display more uniform Brunisolic development because of less extreme exposure. Most stable locations on this aspect have Eluviated Eutric Brunisols associated with altered, medium textured eolian material. Table 271 and Color Plate 49 are informa-

Table 270 General features of the Norquay (NY) Ecosites.

Ecosite	Landform	Soils	Vegetation
NY1	Till C; blanket, veneer	Eutric Brunisol > Regosolic	lodgepole pine forest, Douglas fir forest
NY3	Ice Contact Stratified Drift B; inclined, hummocky	Northerly: Eutric Brunisol Southerly: Regosolic	Northerly: white spruce-Douglas fir forest, lodgepole pine forest Southerly: Douglas fir open and closed forests, low shrub-herb meadow

Figure 47 Landscape schematic showing the relationship of the Norquay (NY) Ecosites to other Ecosites.

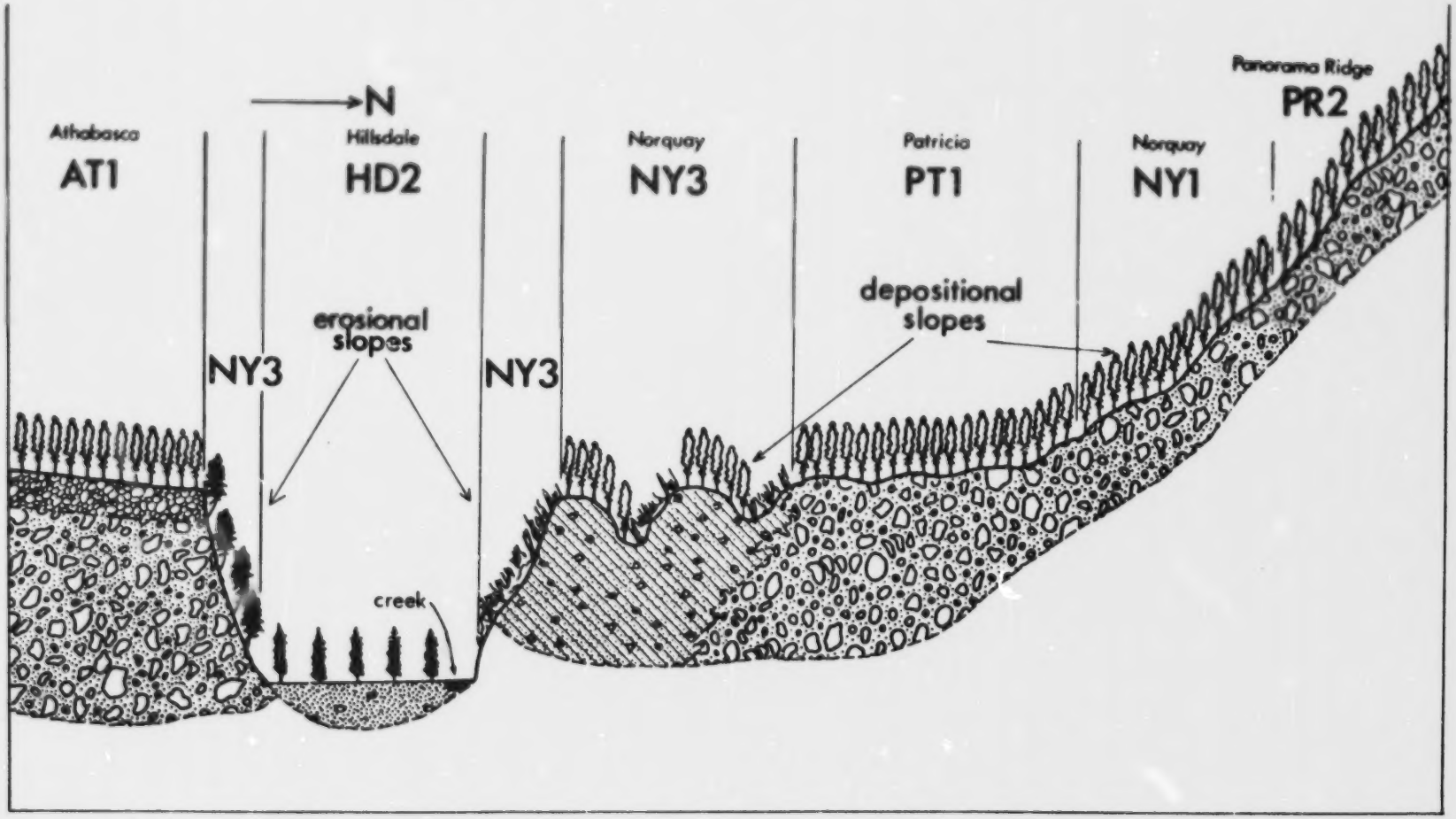


Table 271 Pedon (Alberta 1977 No. 141) describing an Orthic Eutric Brunisol of the NY1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: MAPATZEN: NY1.

LOCATION: MILITARY GRID REF. 11 UPG 20 7250; NTS MAP AREA 820 4E.

CLIMATE: 1490 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS GOOD RELEVANCE TO THE SOIL SITE.

VEGETATION: KEY SPECIES LISTING: 2 1. VPN=PA7193=VTH=C6=.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL), SEDIMENTARY; LANDFORM CLASSIFICATION: MORAINAL, GULLIED, INCLINED; SLOPE: 40% SIMPLE SLOPE OF CLASS 7 (31-45%), FACING NORTHEAST, SITE AT LOWER SLOPE POSITION, LEVEL MICROTOPOGRAPHY.80 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, SLOWLY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY.

SPECIAL NOTES: SBN=NT7270=APN=010-222=RLU=15=SSC=YOR=PCP=26R,1CB(2-3)26R,2CB(4-5),16R(6)38R,2CB(7)=NO SAMPLE OF AE=

L: 1 TO 0 CM, RANGE 1 TO 2 CM; MATRIX MOIST 10YR 3/2; VERY FEW ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AE: 0 TO 1 CM, RANGE 0 TO 3 CM; MATRIX MOIST 10YR 6/2; SILT LOAM; FIRM CONSISTENCE; FEW, FINE ROOTS; FEW, FINE PORES; 10% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

BTJ: 1 TO 8 CM, RANGE 5 TO 9 CM; MATRIX MOIST 10YR 5/4; CLAY LOAM; WEAK TO MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; FEW, MEDIUM AND FINE ROOTS; 10% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

BCK: 8 TO 40 CM, RANGE 28 TO 36 CM; MATRIX MOIST 10YR 5/3; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY WEAK, VERY FINE TO FINE, GRANULAR SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE ROOTS; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; 20% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK1: 40 TO 59 CM, RANGE 18 TO 22 CM; MATRIX MOIST 10YR 6/3; LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, VERY FINE ROOTS; FEW, FINE PORES; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; 20% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK2: 59 TO 62 CM, RANGE 1 TO 5 CM; MATRIX MOIST 7.5YR 5/4; LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, VERY FINE ROOTS; COMMON, FINE PORES; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; COMMON, STREAKED BANDED ; GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK3: 62 TO 105 CM; MATRIX MOIST 10YR 6/4; SILT LOAM; FRIABLE CONSISTENCE; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; 30% GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
L	5.9	38.90	
AE			
BTJ	7.0	3.20	4.5
BCK	7.4		51.9
CK1	7.5		55.7
CK2	7.4		63.5
CK3	7.5		48.9

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
L				
AE				
BTJ	0.1		-.1	
BCK				
CK1				
CK2				
CK3				

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS														
	% PASSING										% OF SAMPLE				
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	78-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
L															
AE															
BTJ										21		50	29	10	
BCK										34		49	17	6	
CK1										40		47	13	4	
CK2										31		44	25	9	2.00
CK3		99	73	64	62					35		51	14	4	

PHYSICAL DATA

	ENGINEERING							
HORIZON	ATTERBERG PLASTIC LIMIT (%)	ATTERBERG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
L								
AE								
BTJ								
BCK								
CK1								
CK2	0.0	0.0					40	SM
CK3								

tion from a pedon chosen to illustrate the soils of NY1. This profile has a thin discontinuous Ae horizon typical of many NY1 soils and a textural luvisolic tendency in the Btj horizon that is frequently observed in Eutric Brunisols in Banff and Jasper. Lithic phases of soils occur on morainal veneers and frequently in a mosaic with rock outcrops. Soils are rapidly to well drained, and seepage, especially on south aspects, is seldom present. Dystric Brunisols dominate NY1 on noncalcareous, medium textured till along the Miette River in Jasper.

Vegetation

The NY1 Ecosite is forested with Douglas fir/hairy wild rye (C1) and lodgepole pine/buffaloberry/showy aster (C6) v.t.s. Vegetation type distribution is influenced by site moisture regime. Stands of C1 are older, successionally mature communities on drier sites, while C6 represents an intermediate to advanced successional stage on moister sites. Table 272 illustrates NY1 vegetation and was sampled at the same site as the NY1 pedon described in Table 271. This C6 stand demonstrates the dry nature of NY1 vegetation even on a moderately exposed east aspect since elements of the more xeric lodgepole pine/juniper/bearberry (C3) v.t. and much Douglas fir are present. More xeric phases of v.t.s often occur with appreciable areas of exposed, erodable mineral soil. Other lodgepole pine/buffalo berry v.t.s such as lodgepole pine/buffaloberry/twinflower (C19) may be expected in NY1, and on more mesic and stable northerly aspects white spruce-Douglas fir/feathermoss (C5) occurs. Douglas fir v.t.s often correlate with shallow to bedrock materials. Minor amounts of v.t.s lodgepole pine/green alder/feathermoss (C10) and lodgepole pine/feathermoss (C11) are present on north aspects on noncalcareous, medium textured till (Till B) mapped as NY1 along the Miette River in Jasper.

Discussion

Evidence of logging still exists on several of the more accessible NY1 tracts. Small patches of grassland are found on steep southerly aspects, most often asociated with Mesozoic aged bedrock. For example Richardson needlegrass-junegrass-everlasting (H13) occurs on the tract containing the road to Mount Norquay ski area in Banff. In Jasper, NY1 mapped in the lower Athabasca and its tributary valleys locally contains Regosolic soils and white spruce vegetation types typical of Talbot (TA3) where the calcareous, medium textured eolian material (Eolian material A) is actively accumulating.

Tracts of NY1+R are mapped frequently on very steep slopes, and often these tracts contain considerable areas of colluvium.

Table 272 Stand (PA7193) illustrating the lodgepole pine/buffaloberry/showy aster (C6) v.t. of the NY1 Ecosite.

TREE LAYER	
Picea glauca	.5
Pinus contorta	40
Pseudotsuga menziesii	15
TALL SHRUB LAYER	
Picea glauca	01
Pinus contorta	01
Pseudotsuga menziesii	03
SHRUB LAYER	
Juniperus scopulorum	.5
Picea glauca	01
Populus tremuloides	.5
Pseudotsuga menziesii	03
Shepherdia canadensis	10
HERB-DWARF SHRUB LAYER	
Arctostaphylos uva-ursi	02
Aster conspicuus	03
Calamagrostis rubescens	08
Elymus innovatus	05
Fragaria virginiana	.5
Hedysarum sulphurescens	01
Juniperus communis	15
Linnaea borealis	02
Pyrola virens	01
Rosa acicularis	01
BRYOID LAYER	
Cladonia cenotea	.5
Cladonia gonecha	.5
Cladonia gracilis	.5
Cladonia multiformis	.5
Cladonia phyllophora	.5
Cladonia pyxidata	.5
Dicranum polysetum	.5
Ditrichum flexicaule	.5
Grimmia apocarpa	.5
Hylocomium splendens	05
Hypnum revolutum	.5
Peltigera canina	.5
Peltigera rufescens	02
Pleurozium schreberi	.5
Pohlia nutans	.5
Psoroma hypnorum	.5
Ptilidium pulcherrimum	.5
Pylaisiella polyantha	.5
Stereocaulon tomentosum	.5
Thuidium abietinum	05
Tortella tortuosa	.5
Tortula ruralis	.5
EPIPHYTES	
Orthotricum anomalum	.5
Hypogymnia physodes	.5
Letharia vulpina	.5
Platismatia glauca	.5
Usnea subfloridana	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Examples are found along the base of the Colin Range bordering the Athabasca River in Jasper.

The NY1 Ecosite is distinguished from NY3 by the characteristics shown in Table 270. Ecosites of the Panorama Ridge Ecosection, especially the PR2 Ecosite, are similar but

occur in the Lower Subalpine rather than Montane. Patricia Ecosites PT1 and PT3 are valley floor units and have a complex ridged landform rather than the simple inclined one of NY1. Vegetation type and soils patterns also reflect the landform difference.

NY3 - NORQUAY 3 ECOSITE

Ecosite Concept

The Norquay 3 Ecosite is characterized by inclined gullied and hummocky calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) in the Montane Ecoregion. Both soils and vegetation are found in a landscape pattern influenced by erosional history and aspect. On northerly aspects, Orthic and Eluviated Eutric Brunisols occur with white spruce-Douglas fir/feathermoss (C5) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s. Drier and warmer southerly aspects typically have rapidly drained Orthic and Cumulic Regosols with Douglas fir/juniper/bearberry (O5), shrubby cinquefoil/bearberry-northern bedstraw (L1), and less frequently Douglas fir/hairy wild rye (C1) v.t.s. An understanding of landscape genesis is important in comprehending the NY3 Ecosite. Linear, inclined, gullied slopes in NY3 are erosional (cf NY1) while complex, hummocky, surface form is depositional (Fig. 47). In both instances landscape with an intricate aspect pattern is produced that in turn influences soil and vegetation development.

The NY3 Ecosite is found on or immediately adjacent to valley floors throughout the Montane Ecoregion.

Geomorphology

The most common genetic material for NY3 is calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). Surficial expression is of two distinct types, inclined and hummocky, both of which contain the contrasting aspects characteristic of NY3. Inclined slopes of this Ecosite are frequently produced by erosion of ice deposited material by present or historical streams. Narrow "V" shaped valleys, incised into benchland, or valley wall slopes undercut by a stream at their base, form the gullied linear 45 to 70% slopes of NY3. This accelerated undercutting erosion acting on weakly cemented material is responsible for the formation of hoodoos. Linear erosional slopes may as frequently be on morainal material. Hummocky topography is a common surface expression resulting from the deposition of ice contact stratified drift. Complex slopes ranging from 15 to 70% are common.

Steep slopes, exposure due to aspect, and erosional undercut of slopes produce a variety of surficial conditions. Steeper slopes on southerly aspects frequently are being actively eroded, and the material distributed downslope as shallow colluvial or fluvial veneers. Locally this erosion may have exposed significant areas of bedrock. Erosional activity may be episodic, and especially northerly aspects may be stable long enough to have accumulations of altered, medium textured eolian material (Eolian material B). This mosaic of stability and instability is influenced by aspect and reflected by the soils and vegetation.

Soils

Soils of NY3 are distributed in a pattern related to aspect and are good indicators of historical stability. Northerly aspect soils are Orthic and Eluviated Eutric Brunisols while soils on southerly aspects are Orthic and Cumulic Regosols. Severe exposure on southerly aspects of erosional slopes inhibits surface stabilization and thus Regosolic soils are maintained. Episodic surface colluviation on steeper slopes or fluvial activity (slope wash) produces Cumulic Regosols, while Orthic Regosols, often with <5 cm Bm horizons, indicate continual soil creep or erosion. Northerly aspect erosional slopes are stabilized more readily and unless otherwise disturbed, Orthic Eutric Brunisols (or Eluviated Eutric Brunisol where altered, medium textured eolian material has accumulated) develop. Hummocky depositional slopes display the same pattern, but Regosolic soils are less extensive because slopes are less steep and erosional undercut is not present to initiate instability.

Table 273 and Color Plate 50 are of a pedon chosen to represent northerly aspect soils of NY3, and Table 274 and Color Plate 51 represent soils with a southerly aspect. The northerly aspect Brunisol is taxonomically adjunct to the Regosolic order because of the Bm horizon's calcium carbonate content and variation of thickness.

The south aspect soil in Table 274 shows a dark yellowish brown weak BCk horizon frequently observed in soils with thin colluvial veneers in calcareous materials. It indicates sufficient stability to produce a thin weathering rind on carbonate grains but does not constitute true B horizon development.

Soils of NY3 are well to rapidly drained, and seepage is seldom observed, especially on south aspects. A textural luvisolic tendency is often present in the B horizons of Brunisolic soils of NY3. Southerly aspects of erosional slopes are frequently a mosaic of lithic soil phases and bedrock outcrops, such as the south aspect along the Miette River in Jasper.

Table 273 Pedon (Alberta 1978 No. 85) describing an Orthic Eutric Brunisol of northerly aspect segments of the NY3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: NY3.

LOCATION: MILITARY GRID REF. 11 UPG 350 7280; NTS MAP AREA 82O 4E.

CLIMATE: 1430 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS GOOD RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 2 DEG(C) AT 50 CM IN MAY.

VEGETATION: VPN=JC6SSE= VTN=CSS=.

SOIL SITE: PARENT MATERIAL 1: COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), GLACIOFLUVIAL AND MORAINAL (TILL); LANDFORM CLASSIFICATION: GLACIO FLUVIAL AND MORAINAL, GULLIED, INCLINED; SLOPE: 52% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING NORTHWEST, SITE AT MIDDLE POSITION, 50 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; SLIGHTLY STONY; NONROCKY.

SPECIAL NOTES: SSH=BWB002=APN=010-223=RLU=18=SSC=CB=PCF=1GR(2-3)1GR(6)=BM FINER TEXTURED THAN OTHER HORIZONS=PARENT MATERIAL PART OF AN ICE-CONTACT STRATIFIED DRIFT COMPLEX=AE NOT SAMPLED=LFH=FB:MI-V=

LF: 5 TO 0 CM, RANGE 3 TO 7 CM; MATRIX MOIST 10YR 2/1; ABUNDANT, FINE AND MEDIUM AND COARSE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 1 CM, RANGE 0 TO 1 CM; MATRIX MOIST 10YR 6/2; SILT LOAM; VERY FRIABLE CONSISTENCE; ABUNDANT, FINE AND MEDIUM AND COARSE ROOTS; MODERATELY POROUS, FEW, VERY FINE PORES; GRAVELLY COARSE FRAGMENTS; BROKEN, ABRUPT HORIZON BOUNDARY.

BM: 1 TO 6 CM, RANGE 2 TO 9 CM; MATRIX MOIST 7.5YR 4/6; SILT LOAM; VERY WEAK, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, FINE AND MEDIUM ROOTS; MODERATELY POROUS; EXTREMELY CALCAREOUS; GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BCK: 6 TO 24 CM, RANGE 14 TO 28 CM; MATRIX MOIST 10YR 3/3; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, GRADUAL HORIZON BOUNDARY.

CK1: 24 TO 66 CM; MATRIX MOIST 10YR 4/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, GRADUAL HORIZON BOUNDARY.

CK2: 66 TO 120 CM; MATRIX DRY 10YR 5/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SLIGHTLY HARD CONSISTENCE; FEW, FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; GRAVELLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LF	7.1	36.96	1.3
AE			
BM	7.1	2.50	3.4
BCK	7.5		48.4
CK1	7.7		58.3
CK2	7.9		50.5

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	0.2		-.1	
BCK				
CK1				
CK2				

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS												
	% PASSING										% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE														
BM										11		69	20	
BCK										16		71	13	
CK1		99	99	99	99					43		50	7	
CK2		99	99	99	98					16		79	5	

PHYSICAL DATA

	MOISTURE STATUS (%)					ENGINEERING							
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE													
BM		24.3	14.5										
BCK													
CK1		11.9	6.1									A8	10
CK2		13.2	5.0									A8	10

Table 274 Pedon (Alberta 1978 No. 84) describing an Orthic Regosol of southerly aspect segments of the NY3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC REGOSOL. SOIL MAP UNIT: NOTATION: NY3.

LOCATION: MILITARY GRID REF. 11 UPG 380 7120; NTS MAP AREA 82O 4E.

CLIMATE: 1420 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS GOOD RELEVANCE TO THE SOIL SITE.

VEGETATION: VPH=JC8081+VTH=82+..

SOIL SITE: PARENT MATERIAL 1: FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL); LANDFORM CLASSIFICATION: MORAINAL, GULLIED, INCLINED; SLOPE: 60% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING SOUTHWEST, SITE AT UPPER SLOPE POSITION, 150 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, SLOWLY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; SLIGHTLY STONY; NONROCKY.

SPECIAL NOTES: SSM=BW8081+APH=010-223+RLU=15+BSC=CB+ST=PCF+36R(2-3)36R,1CB(4)40R,1CB,1ST(5)+SOIL CREEP EVIDENT IN ADDITION TO GULLYING.+LF,BCK NOT SAMPLED+LFH=MI-VF

LF: 1 TO 0 CM, RANGE 0 TO 2 CM; MATRIX MOIST 10YR 2/1; ABUNDANT, VERY FINE AND MEDIUM ROOTS; BROKEN, ABRUPT HORIZON BOUNDARY.

BCK: 0 TO 2 CM, RANGE 0 TO 3 CM; MATRIX MOIST 10YR 3/4; SILT LOAM; VERY WEAK, VERY FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND MEDIUM ROOTS; HIGHLY POROUS, MANY, VERY FINE PORES; STRONG EFFERVESCENCE; 20% GRAVELLY COARSE FRAGMENTS; BROKEN, ABRUPT HORIZON BOUNDARY.

CK1: 2 TO 19 CM, RANGE 7 TO 22 CM; MATRIX MOIST 10YR 6/3; LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY WEAK, FINE, GRANULAR SECONDARY STRUCTURE PSEUDO; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE AND MEDIUM AND COARSE ROOTS; HIGHLY POROUS, MANY, VERY FINE PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 20% GRAVELLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

CK2: 19 TO 40 CM, RANGE 16 TO 23 CM; MATRIX MOIST 10YR 5/3; LOAM; STRUCTURELESS, MASSIVE STRUCTURE; WEAK, FINE, ANGULAR BLOCKY SECONDARY STRUCTURE PSEUDO; FRIABLE, HARD CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; SLIGHTLY POROUS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 20% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

CK3: 40 TO 75 CM; MATRIX DRY 10YR 5/3; GRAVELLY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; WEAK, MEDIUM TO COARSE, PLATY SECONDARY STRUCTURE PSEUDO; FEW, VERY FINE ROOTS; SLIGHTLY POROUS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 30% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LF			
BCK			
CK1	7.7	1.60	50.2
CK2	8.0	0.80	38.4
CK3	8.1	0.80	59.5

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS														
	% PASSING										% OF SAMPLE				
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF															
BCK															
CK1										47		35	18		
CK2		99			73					31		46	23		
CK3		99	62	74	73					32		48	23		0.20

PHYSICAL DATA

	SURVEY (CON'T)								ENGINEERING			
	MOISTURE STATUS (%)											
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
BCK													
CK1		20.1	11.5										
CK2						17.0	23.0		18.0	1.8		40	19
CK3		14.3	6.7			9.0	15.0		8.0	0.0		40	19

Vegetation

Distribution of vegetation types on NY3 demonstrates the strong influence of aspect. Vegetation both reflects and influences surface stability.

Northerly aspects are forested with white spruce-Douglas fir/feathermoss (C5) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s. Though less common, lodgepole pine/buffaloberry/showy aster (C6) and Douglas fir/hairy wild rye (C1) v.t.s also occur on this aspect. In side valleys, such as the Snake Indian River valley in Jasper, close to the upper elevation boundary of NY3, Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t.s are common on northerly aspects. Vegetation is relatively uniform on these slopes.

Southerly aspects of NY3 display a potpourri of microenvironmental conditions through heterogeneity within and between v.t.s. The Douglas fir/juniper/bearberry (O5) v.t. in Banff and shrubby cinquefoil/bearberry-northern bedstraw (L1) v.t. are encountered more frequently than the Douglas fir/hairy wild rye (C1) v.t. Less often observed v.t.s include lodgepole pine/juniper/bearberry (C3), limber pine-Douglas fir juniper/bearberry (O2) (Banff only), junegrass-pasture sage-wild blue flax (H6), and wheatgrass-pasture sage (H7). Distribution of these v.t.s on the landscape is often complex. Southerly aspects are often severely gullied, and denser forest vegetation is found in the draws and less exposed aspects of the ridges. Ridge crests and xeric aspects have low shrub-herb and herb vegetation juxtaposed with dry, open forests. These vegetation types often have appreciable bare mineral soil exposed that is susceptible to erosion. Table 275 describes vegetation found at the northerly facing soil sample site described earlier in Table 273 and Plate 142 illustrates vegetation found on this aspect of NY3.

Table 276 and Plate 36 describe vegetation found at the southerly facing soil sample site described earlier in Table 274 and illustrates vegetation found on this aspect of NY3. The above examples illustrate the effects of different aspect on otherwise similar situations.

More gentle slopes of both linear and irregular landscapes are dominated by the previously mentioned lodgepole pine v.t.s. Patches of aspen/hairy wild rye-peavine (C16) v.t. occur sporadically on warmer aspects of NY3 throughout the Montane. Towards the east gate in Jasper, the lodgepole pine/green alder/feathermoss (C10) v.t. occurs on northerly aspects. Douglas fir forests are often found in association with shallow materials over bedrock. Small areas of wet shrub or herb types exist in some depressional areas in hummocky topography.

Table 275 Stand (JC8002) illustrating the white spruce-Douglas fir/feathermoss (C5) v.t. of northerly aspect segments of the NY3 Ecosite.

TREE LAYER	
Picea glauca	30
Pinus contorta	05
Populus tremuloides	.5
Pseudotsuga menziesii	35
TALL SHRUB LAYER	
Picea glauca	01
Pseudotsuga menziesii	01
SHRUB LAYER	
Juniperus scopulorum	01
Symphoricarpos albus	01
HERB-DWARF SHRUB LAYER	
Amelanchier alnifolia	01
Aster conspicuus	01
Epilobium angustifolium	.5
Juniperus communis	.5
Linnaea borealis	01
Pyrola secunda	.5
Rosa acicularis	.5
Stenanthium occidentale	.5
BRYOID LAYER	
Brachythecium spp.	01
Bryoerythrophyllum recurvirostrum	.5
Bryum spp.	.5
Cladonia coniocraea	.5
Cladonia fimbriata	.5
Cladonia pleurota	.5
Hylocomium splendens	45
Hypnum revolutum	02
Orthotrichum speciosum	.5
Peltigera aphthosa	03
Pohlia nutans	.5
Pylaisiella polyantha	.5
Thuidium abietinum	01
Timmia austriaca	.5
Tortula mucronifolia	01
EPIPHYTES	
Caloplaca stillicidiorum	.5
Cetraria spp.	.5
Hypogymnia physodes	.5
Lecanora coilocarpa	.5
Lecanora spp.	.5
Letharia vulpina	.5
Parmelia exasperatula	.5
Parmelia sulcata	.5
Physcia adscendens	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

Southerly aspects of NY3 are the warmest and driest found in Banff and Jasper. They remain free of snow most of the winter or melt free earliest and most rapidly in spring.

Table 276 Stand (JC8001) illustrating limber pine-Douglas fir/juniper/bearberry (O2), an accessory v.t. of southerly aspect segments of the NY3 Ecosite.

TREE LAYER	
Picea glauca	02
Pinus flexilis	10
Pseudotsuga menziesii	02
TALL SHRUB LAYER	
Pinus flexilis	04
SHRUB LAYER	
Amelanchier alnifolia	.5
Juniperus communis	03
Juniperus scopulorum	17
Potentilla fruticosa	02
Rosa acicularis	01
Shepherdia canadensis	.5
HERB-DWARF SHRUB LAYER	
Allium cernuum	.5
Anemone multifida	.5
Anemone patens	.5
Antennaria nitida	.5
Arctostaphylos uva-ursi	20
Artemisia frigida	.5
Aster ciliolatus	.5
Astragalus spp.	.5
Carex filifolia	.5
Erigeron caespitosus	.5
Hedysarum mackenzii	.5
Linum lewisii	.5
Oxytropis sericea	.5
Rosa acicularis	.5
Senecio canus	.5
Trisetum spicatum	.5
Trisetum spp.	.5
BRYOID LAYER	
Barbula icmadophila	.5
Encalypta rhaptocarpa	.5
Pylaisiella polyantha	.5
Tortula ruralis	.5
Xanthoria elegans	.5
EPIPHYTES	
Letharia vulpina	.5
Parmelia infumata	.5
Parmelia subolivacea	.5
Usnea hirta	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Both chinooks and incident solar radiation contribute to this condition. It is suspected that wildlife use of these slopes contributes to both the sparse vegetation and eroded soil condition. Fire history is another significant factor. Tracts of NY3 bordering the Athabasca River in Jasper downstream from Henry House and bordering the North Saskatchewan and Howse Rivers in Banff may have patchy accumulations of calcareous, medium textured eolian material (Eolian material A). These local areas will resemble the Talbot (TA) Ecosection but occur in tracts too small to be delineated at a map scale of 1:50,000.

Evidence of logging still exists on several more accessible tracts of NY3. Erosional canyon forms of NY3 frequently have the stream that carved them and their associated fluvial deposits along their length at the bottom. These linear fluvial deposits that are too small to separate cartographically have characteristics of the Hillsdale (HD) Ecosection.

Tracts of NY3+R are frequently mapped on erosional slopes, and often contain considerable areas of colluvium and lithic soils.

The NY3 Ecosite most closely resembles the Ecosites GT1, GT2, and PR4, but these are Lower Subalpine counterparts. The NY1 Ecosite shows more uniformity in vegetation, and is restricted to morainal slopes with surface expression controlled by deposition. Patricia (PT) Ecosites are found on valley bottom morainal situations with a more uniform soil and vegetation distribution pattern than that of NY3.

PL - PEYTO LAKE ECOSECTION

The Peyto Lake (PL) Ecosection is one of the most extensive in Banff and Jasper and encompasses morainal landforms comprised of calcareous, medium textured till (Till C) throughout the Upper Subalpine portion of the Subalpine Ecoregion. It occurs on valley walls, floors, and shoulders, and in cirque basins and cols and is associated with calcareous strata.

The dominant soils, Eutric Brunisols, are moderately developed and reflect the calcareous, medium textured parent material and cool, moist Upper Subalpine environment. Engelman spruce-subalpine fir closed and open forest, subalpine larch-subalpine fir forest, a distinctive pattern of tundra plus coniferous open forest, and a dry > wet landscape pattern differentiate the four Peyto Lake (PL) Ecosites (Table 277). Fig. 48 shows, schematically, the physiographic positions of the Peyto Lake Ecosites and their relationship to a few other Upper Subalpine and Alpine Ecosites occurring on calcareous, medium textured till.

PL1 - PEYTO LAKE 1 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, PL1, occurs on morainal blankets consisting of calcareous, medium textured till (Till C) overlying inclined bedrock on valley walls. Orthic and Eluviated Eutric Brunisols are the dominant soils. Vegetation cover is dominated by the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21), and Engelmann spruce-subalpine fir/heather (O10) v.t.s. The C15 and O10 v.t.s. are most abundant but some PL1 tracts are dominated by C21 or by C21 plus O10.

Figure 48 Landscape schematic showing the relationship of the Peyto Lake (PL) Ecosites to other Ecosites.

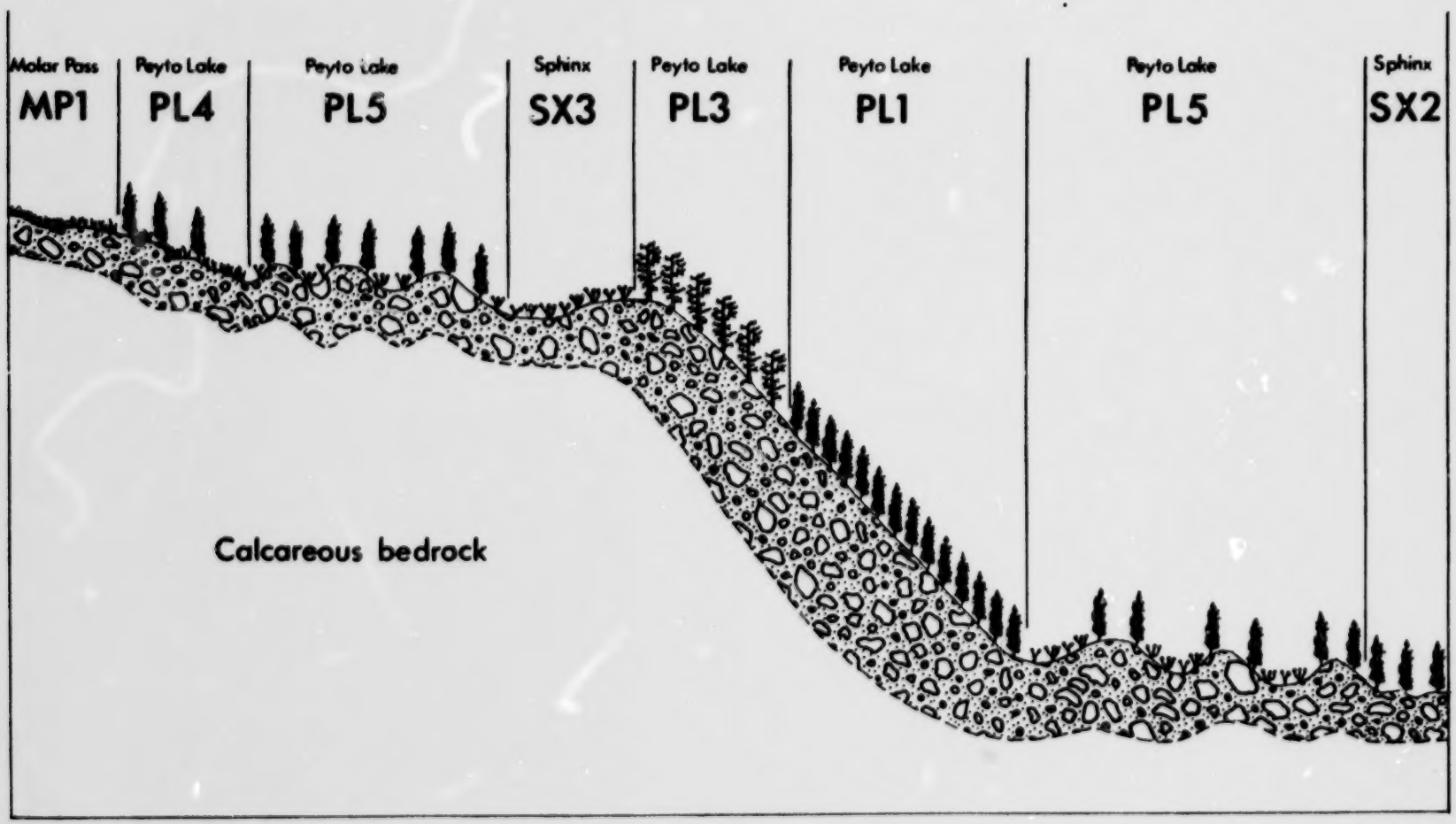


Table 277 General features of the Peyto Lake (PL) Ecosites.

Ecosite	Landform	Soils	Vegetation
PL1	Till C; blanket	Eutric Brunisol	Engelmann spruce-subalpine fir closed and open forests
PL3	Till C; blanket	Eutric Brunisol > Humo-Ferric Podzol	subalpine larch-subalpine fir forest
PL4	Till C; blanket, veneer	Eutric Brunisol > Melanic Brunisol, Ferro-Humic Podzol	heath tundra > Engelmann spruce-subalpine fir open forest
PL5	Till C; blanket, veneer	Dry[m]: Eutric Brunisol Wet[m]: Gleysolic, gleyed Podzolic, gleyed Brunisolic	Dry[m]: Engelmann spruce-subalpine fir closed and open forests, subalpine larch-subalpine fir forest Wet[m]: wet shrub thicket

Geomorphology

The PL1 Ecosite is typified by morainal blankets overlying inclined bedrock on valley walls. These moraines consist of calcareous, medium textured till (Till C). Surface veneers of altered, medium textured eolian material (Eolian material B) are important where they are extensively distributed, on PL1 tracts located in western Banff and southwestern Jasper. Colluvium derived from till and/or fractured bedrock is found occasionally on the steepest portions of the landscape. Moraine-like glacial landforms consisting of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) occur occasionally, most notably in the Sunwapta Pass area of Banff and Jasper.

Topographically the PL1 Ecosite displays long, linear slopes consisting of till mantling the inclined bedrock that forms valley walls. Slopes commonly range from 15 to 70% and are often dissected by subparallel gullies oriented perpendicular to the contour. Small fluvial fans and aprons emanating from gully mouths along valley bottoms or other major slope breaks may be included in tracts mapped as PL1. Patches of colluvium existing as blankets and veneers occur occasionally on the steepest terrain. Tracts of PL1 situated along valley floors, at valley confluences, on valley shoulders, in cirque basins and cols, and on failed slopes often display irregular surfaces and complex topography (5-45% slopes). These landforms include morainal blankets and veneers overlying ridged and hummocky bedrock and the relatively deep till or ice contact stratified drift of hummocky glacial landforms. Morainal veneers dominate in PL1X tracts. Bedrock outcrops occur occasionally but are abundant on PL1 + R tracts.

Soils

The soils of the PL1 Ecosite are dominated by Orthic and Eluviated Eutric Brunisols. These well to moderately well drained soils have B horizons that range from the rudimentary textural horizons frequently associated with weathering of calcareous till to the comparatively well developed Bm and Bf horizons associated with altered, medium textured eolian material (Eolian material B). The accessory soils, Orthic Humo-Ferric Podzols, are genetically related and most common on the PL1 tracts with extensive veneers of Eolian material B. Orthic and Brunisolic Gray Luvisol soils occur in minor amounts. Soils with luvisolic tendencies are especially evident on the drier slopes of eastern Banff and Jasper. Soils with Bhf horizons occur occasionally. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly expressed in the absence of Eolian material B. In some localities Ae horizons have been destroyed by recent erosional processes such as avalanching, gullying, windthrow of trees, or shallow surface colluviation. Some gullies and depressional localities contain seeps with associated wet soils. Orthic and Cumulic Regosols occur on steep, colluviating portions of the landscape. Some PL1 tracts associated with material derived from Mesozoic strata have small, steeply sloping grassland patches where Orthic Melanic Brunisols occur. Lithic soil phases are not common except on tracts mapped as PL1X, where they dominate.

A pedon illustrating Orthic Eutric Brunisols of the PL1 Ecosite is described in Table 278. The upper solum of this pedon has been disturbed and the eolian veneer reworked and mixed with till, probably by slowly flowing surface water. Hence, an Ae horizon is missing and the upper solum is relatively fine textured. Note also that the till has an exceptionally high $CaCO_3$ equivalent.

Vegetation

The PL1 Ecosite is dominated by the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21), and Engelmann spruce-subal-

Table 278 Pedon (Alberta 1977 No. 147) describing an Orthic Eutric Brunisol of the PL1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: PL1.

LOCATION: MILITARY GRID REF. 11 UNB 7360 9390; NTS MAP AREA 820 SW.

CLIMATE: 2150 ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VTH=C15*.

SOIL SITE: PARENT MATERIAL 1: FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), EOLIAN; PARENT MATERIAL 2: COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL); LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 58% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING SOUTHWEST, SITE AT UPPER SLOPE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY.100 M LONG; SOIL MOISTURE AND DRAINAGE: MODERATELY WELL DRAINED, SLOWLY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; SLIGHTLY STONY; NONROCKY.

SPECIAL NOTES: SSH=BC7854+APH=783-104+RLU=15+MLU=82+SSC=C0+PCP=10R(2)2GR.1CB(3)3GR.2CB(4-5)=ABUNDANT WHITE MYCELIA IN FH+LARGE DECOMPOSED ROOT NEAR BOTTOM OF BH=2CK2 SAMPLED FROM 105 TO 110CM=LFH+MB/RI*

FH: 101 TO 201 CM, RANGE 1 TO 2 CM; HORIZON MOIST; NATURAL WET/OXIDIZED 5YR 2.5/1; SMOOTH, ABRUPT HORIZON BOUNDARY.

BH: 0 TO 20 CM, RANGE 15 TO 23 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/5; SILTY CLAY LOAM; MODERATE, FINE GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, FINE AND MEDIUM ROOTS; FEW, FINE PORES; GRAVELLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2BCK: 20 TO 32 CM, RANGE 18 TO 15 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/4; SILTY CLAY LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; MODERATE, FINE, GRANULAR SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MEDIUM ROOTS; FEW, FINE PORES; WEAK EFFERVESCENCE; WEAKLY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2CK1: 32 TO 70 CM, RANGE 33 TO 43 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/3; SILT LOAM; MASSIVE STRUCTURE; WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE PSEUDO; FRIABLE CONSISTENCE; FEW, MEDIUM ROOTS; COMMON, FINE PORES; FEW, VERY THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; MODERATE EFFERVESCENCE; VERY STRONGLY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2CK2: 70 TO 110 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/3; SILT LOAM; MASSIVE STRUCTURE; FIRM CONSISTENCE; FEW, FINE PORES; FEW, VERY THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; MODERATE EFFERVESCENCE; VERY STRONGLY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
FH	5.7	37.30							
BH	5.2	2.70		19.7		12.1	1.0	0.1	0.3
2BCK	6.9		23.9						
2CK1	7.3		74.8						
2CK2	7.4		66.3						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
FH				
BH	0.3		0.1	
2BCK				
2CK1				
2CK2				

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
FH										8		63	29	9	1.20
BH										14		54	28	10	1.30
2BCK										37		50	13	5	2.20
2CK1										33		50	17	5	2.30
2CK2	99	72	58	52											

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
FH								
BH								
2BCK								
2CK1								
2CK2	12.0	17.0					40	18

pine fir/heather (O10) v.t.s. The C15 and O10 v.t.s are most abundant. Immediately above the boundary between Lower and Upper Subalpine C15 is the most abundant. The O10 v.t. occurs above C15 and is most extensive on northerly aspects. Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) replaces C15 throughout northern Jasper (north of the range of *Vaccinium scoparium*) and on many PL1 tracts near the Continental Divide. One accessory v.t., Engelmann spruce-subalpine fir/heather/feather moss (C34), often occurs above C15 or C21 and below O10. The other accessory v.t., Engelmann spruce/hairy wild rye (C33), is common on comparatively dry, steep, southerly aspects in eastern Banff and Jasper. Associated soils are predominantly Orthic Eutric Brunisols with luvisolic tendencies and little or no veneer of altered, medium textured eolian material. Various moist to wet Upper Subalpine v.t.s. such as Engelmann spruce-subalpine fir/valerian-fleabane (O9) or willow/cinquefoil (S8) are associated with seeps found in some gullies and depressional sites. Hairy wild rye-junegrass-bearberry (H14) associated with Orthic Eutric and Orthic Melanic Brunisols dominate the small, steeply sloping, grassland patches included on some PL1 tracts in eastern Banff and Jasper. These tracts occur on till containing a significant amount of material derived from Mesozoic strata. Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feather-moss (C31) on southerly aspects, and Engelmann spruce-subalpine fir/rock willow/white mountain heather (C24) on northerly aspects, also occur in small amounts on this Front Ranges till. Snow avalanche v.t.s such as subalpine fir-willow (S2) occur on avalanched portions of the landscape (PL1A). Fire affected vegetation in which spruce is regenerating occurs in some areas (e.g. tracts mapped as PL1A in the Sawback Creek area of Banff). On a few PL1 tracts in eastern Banff and Jasper, unusually high elevation lodgepole pine stands resembling the lodgepole pine/buffaloberry/grouseberry (C18) v.t. occur, following fires, on southerly aspects.

A stand illustrating the C15 v.t. of the PL1 Ecosite is described in Table 279. This stand is located about 1 km downvalley and on the same slope as the pedon sample site described above (Table 278).

Table 279 Stand (AW5137) illustrating the Engelmann spruce-subalpine fir/grouseberry (C15) v.t. of the PL1 Ecosite.

TREE LAYER	
Abies lasiocarpa	26
Picea engelmannii	10
TALL SHRUB LAYER	
Abies lasiocarpa	02
Picea engelmannii	.5
SHRUB LAYER	
Abies lasiocarpa	13
Picea engelmannii	01
Salix vestita	01
HERB-DWARF SHRUB LAYER	
Arnica cordifolia	02
Castilleja occidentalis	.5
Erigeron peregrinus	.5
Fragaria virginiana	.5
Moneses uniflora	.5
Osmorhiza chilensis	.5
Pedicularis bracteosa	.5
Phyllodoce empetriformis	.5
Pyrola secunda	.5
Pyrola virens	.5
Senecio indecorus	.5
Stenanthium occidentale	.5
Trollius albiflorus	.5
Vaccinium scoparium	13
Valeriana sitchensis	.5
Equisetum scirpoides	.5
BRYOID LAYER	
Barbilophozia spp.	06
Brachythecium spp.	15
Cladonia spp.	01
Dicranum spp.	03
Drepanocladus uncinatus	45
Hylocomium splendens	02
Peltigera aphthosa	04
Pleurozium schreberi	01
EPIPHYTES	
Alectoria spp.	.5
Letharia vulpina	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The PL1 Ecosite is the most extensive of the Peyto Lake Ecosites. In physiographic position, landform surface expression, and vegetation cover PL1 resembles the Egypt 1 (EG1) and Larch Valley 3 (LV3) Ecosites. However, rather than the Till C of PL1, EG1 occurs on morainal landforms consisting of noncalcareous, medium textured till (Till B) and LV3 occurs on noncalcareous, coarse textured till (Till A). Both EG1 and LV3 are dominated by Dystric rather than Eutric Brunisols. Also LV3 soils have significantly thicker sola. The PL1 Ecosite is differentiated from other Peyto Lake Ecosites by vegetation cover and amount of wet, seepage affected landscape as outlined in Table 277. The Bryant 1 and 2 (BY1, BY2) Ecosites are the Lower Subalpine counterparts of PL1.

PL3 - PEYTO LAKE 3 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, PL3, occurs on morainal blankets consisting of calcareous, medium textured till (Till C) overlying inclined, hummocky, or ridged bedrock. Veneers of altered, medium textured eolian material (Eolian material B) occur extensively and significantly affect soil development. Consequently,

PL3 exhibits a soil pattern in which Eluviated Eutric Brunisols are dominant, Orthic Eutric Brunisols and Orthic Humo-Ferric Podzols subdominant. Vegetation cover is dominated by the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. The PL3 Ecosite is the least extensive of the Peyto Lake Ecosites and is found only in Banff south of Hector Lake, Pipestone Pass, and the Panther River.

Geomorphology

The PL3 Ecosite is typified by morainal blankets overlying inclined, hummocky, or ridged bedrock. These moraines consist of calcareous, medium textured till (Till C). Veneers of altered, medium textured eolian material (Eolian material B) occur extensively. Colluvium derived from till and/or fractured bedrock is found occasionally on steepest portions of the landscape, particularly below bedrock escarpments. Glacial landforms consisting of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) occur rarely in tracts mapped as PL3.

Topographically, PL3 displays linear, inclined slopes on upper valley walls or hummocky and ridged surfaces on valley shoulders, cirque basins, and cols. These surface expressions usually relfect underlying bedrock surfaces. Slopes commonly range from 5 to 45%. The linear slopes are often gullied. Patches of colluvium existing as blankets and veneers occur occasionally on the steepest terrain, particularly below bedrock escarpments. Morainal veneers and bedrock outcrops occur occasionally. On tracts mapped as PL3X veneers of morainal material dominate and bedrock outcrops are more common than normal for PL3. Comparatively deep till deposits, usually with a hummocky surface form, occur occasionally on cirque floors and failed slopes.

Soils

Eluviated Eutric Brunisols are the dominant soils of the PL3 Ecosite; Orthic Eutric Brunisols and Orthic Humo-Ferric Podzols are the subdominant soils. These soils reflect the presence of nearly continuous veneers of altered, medium textured eolian material (Eolian material B) in that they have comparatively distinct Bm, Bf, or podzolic Bf horizons above the parent material disconformity and weakly developed Bm or BC horizons below. These lower horizons may exhibit clay increases when compared to those above the disconformity. Orthic Eutric Brunisols and others lacking well developed Ae horizons occur in localities recently affected by erosional processes such as avalanching, gullying, or shallow surface colluviation or where significant humus incorporation masks the effects of eluviation. Most PL3 soils show, in their upper sola, humic enrichment consistent with the near Alpine environment and the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. Consequently soils with Bhf and podzolic Bhf horizons occur occasionally. Minor amounts of various wet soils are associated with seeps in depressional portions of the landscape. Lithic soil phases are abundant only on PL3X tracts. Regosolic soils on colluviating sites occur rarely.

A pedon illustrating Eluviated Eutric Brunisols of the PL3 Ecosite is described in Table 280 and shown in Color Plate 52. Note that this profile has a Bm below a Bf horizon both in the eolian veneer and a IICk1 horizon immediately below the parent material disconformity. Both the Bm and IICk1 horizons show higher clay contents than the Ae horizon. The dark color of the till parent material is attributable to incorporation of material from Mesozoic strata.

Vegetation

The PL3 Ecosite is dominated by the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. An open tree canopy variant of C23 occurs on exposed sites and along the upper elevational boundaries of PL3 tracts. Stunted variants or other avalanche v.t.s such as subalpine fir-willow (S2) occur on avalanched portions of the landscape (mapped as PL3A). Because they occur in areas too small to be delineated at a 1:50,000 scale, many PL3 tracts have minor amounts of Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21), or Engelmann spruce-subalpine fir/heather (O10) along lower elevational boundaries, and patches of heather-everlasting (L5) along upper boundaries. Various moist to wet Upper Subalpine v.t.s as well as C23 are associated with seeps in depressional localities. Burned variants of C23 occur occasionally in fire affected areas (e.g. areas mapped as PL3B in the Cascade Mountain area of Banff). A stand representing vegetation of the pedon sample site described above (Table 280) and illustrating the open phase of C23 on the PL3 Ecosite is presented in Table 281 and Plate 143.

Discussion

The PL3 Ecosite is the least extensive of the Peyto Lake Ecosites. Its distribution is governed by the geographic range of subalpine larch-subalpine fir/grouseberry-everlasting (C23) on Till C. In physiographic position, landform surface expression, and vegetation cover, PL3 resembles the Egypt 2 (EG2) and Larch Valley 1 (LV1) Ecosites. However, unlike the Till C of PL3, EG2 occurs on

Table 280 Pedon (Alberta 1978 No. 79) description of an Eluviated Eutric Brunisol of the PL3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: PL3.

LOCATION: MILITARY GRID REF. 11 UNB 9029 9270; NTS MAP AREA 820 SE.

CLIMATE: 2190 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 3 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VPN=JE0161+VTN=CZ3+.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), EOLIAN, SEDIMENTARY; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL), SEDIMENTARY; LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 15% COMPLEX SLOPE OF CLASS 6 (16-30%), SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,70 M LONG; SOIL MOISTURE AND DRAINAGE: MODERATELY WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; SLIGHTLY STONY; NONROCKY.

SPECIAL NOTES: SSH=WT8150+APH=010-219+RLU=18+PCF=10R,1CB(2-5)2BR,2AGR,2CB,2ACB,1ST(6)3BR,2AGR,2CB,2ACB,1ST(7)+LFPH=B/BH+

LF: -3 TO 0 CM, RANGE 2 TO 4 CM; MATRIX MOIST 7.5YR 3/2; ABUNDANT, MEDIUM AND COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AHE: 0 TO 3 CM, RANGE 0 TO 4 CM; MATRIX MOIST 10YR 4/1; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; 10% COBBLY AND GRAVELLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

AE: 3 TO 7 CM, RANGE 2 TO 4 CM; MATRIX MOIST 10YR 6/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; 10% COBBLY AND GRAVELLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

BF: 7 TO 15 CM, RANGE 6 TO 10 CM; MATRIX MOIST 5YR 5/6, MATRIX MOIST 7.5YR 6/8; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; 10% COBBLY AND GRAVELLY COARSE FRAGMENTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

BH: 15 TO 30 CM, RANGE 13 TO 17 CM; MATRIX MOIST 7.5YR 6/4; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; 10% COBBLY AND GRAVELLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2CK1: 30 TO 80 CM, RANGE 45 TO 55 CM; MATRIX MOIST 10YR 2/1; SILTY CLAY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; STRONG EFFERVESCENCE; MODERATELY CALCAREOUS; 30% COBBLY AND ANGULAR COBBLY AND STONY (BOULDERY) AND GRAVELLY AND ANGULAR GRAVELLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2CK2: 80 TO 115 CM; MATRIX MOIST 10YR 5/1; LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 40% COBBLY AND GRAVELLY AND ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUF?.	PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.6	30.90							
AHE	4.3	7.60		23.5		10.5	2.1	0.1	0.5
AE	4.3	3.20		13.8		4.4	1.0	0.1	0.1
BF	5.2	4.60		26.4		9.3	1.1	0.1	0.1
BH	5.2	0.60		11.5		11.7	3.2	-.1	0.1
2CK1	6.9		9.8						
2CK2	7.3		42.5						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2
LF				
AHE				
AE				
BF	0.5		0.4	
BH	0.2		-.1	
2CK1				
2CK2				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70- 2U SILT	50- 2U SILT	2U CLAY	0.2U CLAY
LF														
AHE										10		77	13	
AE										17		75	8	
BF										13		78	9	
BH										10		66	24	
2CK1	99			74						12		57	31	
2CK2	99	84	52	38						42		48	10	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AHE													
AE		18.6	13.3										
BF													
BH													
2CK1		30.3	13.9			25.0	38.0		26.0	1.5		69	99
2CK2		14.7	5.2			17.0	18.0		14.0	1.8		12	97

Table 281 Stand (JE8161) illustrating the subalpine larch-subalpine fir/ grouseberry-everlasting (C23) v.t. of the PL3 Ecosite.

TREE LAYER	
Abies lasiocarpa	02
Larix lyallii	08
Picea engelmannii	05
TALL SHRUB LAYER	
Abies lasiocarpa	05
Larix lyallii	08
Picea engelmannii	06
SHRUB LAYER	
Abies lasiocarpa	01
Larix lyallii	02
Picea engelmannii	01
Salix glauca	.5
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	02
Achillea millefolium	.5
Anemone drummondii	.5
Anemone occidentalis	.5
Antennaria lanata	.5
Antennaria nitida	.5
Antennaria racemosa	.5
Arenaria capillaris	.5
Arenaria rubella	.5
Arnica cordifolia	.5
Carex phaeocephala	.5
Fragaria virginiana	.5
Gentiana propinqua	.5
Hieracium gracile	.5
Juncus drummondii	.5
Larix lyallii	.5
Phleum alpinum	.5
Phyllodoce glanduliflora	35
Picea engelmannii	.5
Poa alpina	.5
Potentilla diversifolia	.5
Pyrola secunda	.5
Senecio spp.	.5
Sibbaldia procumbens	.5
Trisetum spicatum	.5
Vaccinium scoparium	20
Valeriana sitchensis	.5
Veronica alpina	.5
Equisetum scirpoides	.5
BRYOID LAYER	
Cladonia ecmocyna	.5
Cladonia gonecha	.5
Cladonia pleurota	.5
Lecidea granulosa	.5
Peltigera spuria	.5
Polytrichum spp.	.5
Tortula ruralis	.5
EPIPHYTES	
Cetraria pinastri	.5
Letharia vulpina	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

morainal landforms consisting of noncalcareous, medium textured till (Till B) and LV1 occurs on noncalcareous, coarse textured till (Till A). Both EG2 and LV1 are dominated by Dystric rather than Eutric Brunisols. Also LV1 soils have significantly thicker sola. The PL3 is differentiated from other Peyto Lake Ecosites by vegetation cover and the amount of wet, seepage affected, landscape as outlined in Table 277.

PL4 - PEYTO LAKE 4 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, PL4, occurs on morainal blankets and veneers consisting of calcareous, medium textured till (Till C) overlying inclined, hummocky, and ridged bedrock. A soil pattern relating to the amount of humus accumulation and presence of veneers of altered, medium textured eolian material (Eolian material B) characterizes PL4. Orthic and Eluviated Eutric Brunisols are dominant; Orthic Melanic Brunisols and Orthic Ferro-Humic Podzols are subdominant. A distinct pattern comprised of heather-everlasting (L5) interspersed with islands of Engelmann spruce-subalpine fir/heather (O10) characterizes the vegetation component of this Ecosite. The PL4 Ecosite represents the uppermost part of the Upper Subalpine on Till C and is normally bounded above by Alpine Ecosites, below by Upper Subalpine Ecosites with closed to open forests of Engelmann spruce-subalpine fir or subalpine larch-subalpine fir.

Geomorphology

The PL4 Ecosite is typified by morainal blankets and veneers overlying inclined, hummocky, and ridged bedrock. These moraines consist of calcareous, medium textured till (Till C). Surface veneers of altered, medium textured eolian material (Eolian material B) occur extensively on PL4 tracts of western Banff and southwestern Jasper, sporadically elsewhere. Colluvium derived from till and/or fractured bedrock is found occasionally on the steepest portions of the landscape. Glacial landforms consisting of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) occur rarely in tracts mapped as PL4.

Topographically, PL4 displays linear, inclined slopes on upper valley walls or hummocky and ridged surfaces on valley shoulders, cirque basins, and cols. These surface expressions usually reflect the underlying bedrock surfaces. Slopes range from 5 to 70%. The linear slopes are often gullied. Morainal veneers are common and dominate on tracts mapped as PL4X. Bedrock outcrops are most common on PL4+R tracts. Colluvial blankets and veneers occur locally on the steepest terrain, particularly below bedrock escarpments. Comparatively deep till deposits, usually with a hummocky surface form, occur occasionally on cirque floors and failed slopes.

Table 282 Pedon (Albeta 1979 No. 67) description of an Eluviated Eutric Brunisol of the PL4 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: PL4.

LOCATION: MILITARY GRID REF. 11 UNJ 4680 975; NTS MAP AREA 83C 6W.

CLIMATE: 2150 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS POOR RELEVANCE TO THE SOIL SITE.

VEGETATION: VPN=LC9182WVTN=018W.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN, UNDIFFERENTIATED OR UNDETERMINED; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL); LANDFORM CLASSIFICATION: MORAINAL, RIDGED; SLOPE: 15% COMPLEX SLOPE OF CLASS 5 (10-15%), FACING WEST, SITE AT UPPER SLOPE POSITION, STRONGLY ROUNDED MICROTOPOGRAPHY,80 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY.

SPECIAL NOTES: SSN=NT9161<APN=015-058<RLU=15<PCP=10R(2-3)2GR,2CB,1FL(4)3BR,3CB(5)3BR,2AG,3CB(6)>LPH=EV/YR=TERMINAL MORAINE OF CIRQUE GLACIER<DATE=SEPT.22,1979>

LF: 2 TO 0 CM, RANGE 1 TO 3 CM; MATRIX MOIST 10YR 2/2; PLENTIFUL, FINE AND VERY FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 5 CM, RANGE 3 TO 7 CM; MATRIX MOIST 7.5YR 6/2, MATRIX MOIST 7.5YR 7/2; SILT LOAM; WEAK, MEDIUM, PLATY STRUCTURE; WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MEDIUM AND COARSE ROOTS; COMMON, HORIZONTAL, EXPED PORES; WAVY, CLEAR HORIZON BOUNDARY.

BHF: 5 TO 9 CM, RANGE 4 TO 9 CM; MATRIX MOIST 7.5YR 5/7, MATRIX MOIST 5YR 3/4; SILT LOAM; WEAK TO MODERATE, VERY FINE TO FINE, SUBANGULAR BLOCKY STRUCTURE; VERY WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, MEDIUM AND COARSE ROOTS; COMMON, EXPED PORES; IRREGULAR, CLEAR HORIZON BOUNDARY.

2BM: 9 TO 18 CM, RANGE 5 TO 10 CM; MATRIX MOIST 10YR 5/4; SILT LOAM; MODERATE TO STRONG, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; FEW, MEDIUM ROOTS; FEW, VERY THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY, 10YR 4/3; WAVY, GRADUAL HORIZON BOUNDARY.

2BCK: 18 TO 31 CM, RANGE 10 TO 16 CM; MATRIX MOIST 10YR 4/3, MATRIX MOIST 10YR 5/2; SILTY CLAY LOAM; MODERATE TO STRONG, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; FEW, FINE AND MEDIUM ROOTS; FEW, VERY THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY, 10YR 4/3; VERY WEAK EFFERVESCENCE; WEAKLY CALCAREOUS; WAVY, GRADUAL HORIZON BOUNDARY.

2CK: 31 TO 85 CM; MATRIX MOIST 2.5Y 5/4; SILT LOAM; MODERATE TO STRONG, MEDIUM TO COARSE, SUBANGULAR BLOCKY STRUCTURE PSEUDO; FIRM CONSISTENCE; VERY FEW, FINE ROOTS; COMMON, VERY THIN CLAY FILMS IN MANY VOIDS/CHANNELS AND ON SOME VERTICAL AND HORIZONTAL PED FACES, 2.5Y 5/4; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.8	48.40							
AE	4.6	3.60		20.7		4.2	0.4	0.1	0.1
BHF	5.9	7.80		45.4		30.6	2.1	0.1	0.1
2BM	6.3	1.40		20.9		18.7	1.3	-.1	0.1
2BCK	6.8		2.3						
2CK	7.5		53.2						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BHF	0.7		0.5	
2BM	0.2		-.1	
2BCK				
2CK				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	% OF SAMPLE 50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF															
AE										15		72	13		1.40
BHF										16		71	13		
2BM										17		59	24		
2BCK										14		53	33		
2CK	99	84	54	46						31		52	17		2.00

PHYSICAL DATA

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AE								
BHF								
2BM								
2BCK								
2CK	18.0	23.0		16.0	1.8		24	10

Soils

A soil pattern in which Orthic and Eluviated Eutric Brunisols are dominant and Orthic Melanic Brunisols and Orthic Humo-Ferric Podzols subdominant characterizes the PL4 Ecosite. In the near Alpine environment, organic matter accumulation in the upper sola of these well to moderately well drained soils is significantly greater than on other Peyto Lake Ecosite soils. Thus the effects of eluviation are often masked and PL4 soils have varying thicknesses of Ah and/or Ahe horizons. Most Brunisolic soils of PL4 have acidic upper sola with low base saturation. Consequently, PL4 soils display, from surface to C horizons, abruptly increasing pH. Where veneers of altered, medium textured eolian material (Eolian material B) are present, these soils often have comparatively distinct podzolic Bhf and occasionally Podzolic Bf horizons above and weakly developed Bm or BC horizons below the parent material disconformity. The lower Bm or BC horizons may have higher clay content than horizons above or below. Turbic soil phases produced by cryoturbation and solifluction are common among PL4 soils, particularly on PL4 tracts in the eastern part of both parks. Lithic phases of soil subgroups are associated with the morainal veneers and dominate on tracts mapped as PL4X. Depressional localities with various seepage affected, wet soils may constitute up to 20% of PL4 tracts. Regosolic soils occur occasionally on severely soliflucted, cryoturbated, and colluviated sites.

A pedon illustrating Eluviated Eutric Brunisols of the PL4 Ecosite is described in Table 282 and shown in Color Plate 53. This pedon does not have the Ah or Ahe horizons common to PL4 soils but it does have a thin, well developed Bhf horizon with high organic carbon content. The ridged morainal landform at this sample site is local (terminal moraine from a cirque) and is the result of glacial deposition rather than bedrock control.

Vegetation

The PL4 Ecosite is dominated by a vegetation pattern in which the heather-everlasting (L5) v.t. is more abundant than the Engelmann spruce-subalpine fir/heather (O10) v.t. The O10 v.t. normally exists as discrete patches or islands of trees but includes islands of krummholz on exposed sites or at the Upper Subalpine-Alpine boundary. Within the elevational range of the PL4 Ecosite, tree islands cover about 50% of the landscape at lowest elevations and 5% at the highest elevations. Islands of subalpine larch-subalpine fir/grouseberry-everlasting (C23) often replace O10 in PL4 tracts located in southern Banff. Patches of white mountain heather-mountain avens-snow willow (L4) and mountain avens-snow willow-moss campion (H1) occur occasionally, H1 being restricted to exposed ridge and hummock crests. Seepage affected depressional localities often have moist to wet Upper Subalpine v.t.s such as Engelmann spruce-subalpine fir/valerian-fleabane (O9), willow/cinquefoil (S8), or mountain marigold-globeflower (H9). Modification by avalanching (mapped as PL4A) and fire (mapped as PL4B), although difficult to identify on PL4 vegetation, occurs occasionally. A stand representing vegetation of the pedon sample site and illustrating the O10 segment of the PL4 vegetation pattern is presented in Table 283 and Plate 144.

Table 283 Stand (LC9182) illustrating the Engelmann spruce-subalpine fir/heather (O10) portion of the v.t. pattern of the PL4 Ecosite.

TREE LAYER	
Abies lasiocarpa	04
Picea engelmannii	08
TALL SHRUB LAYER	
Picea engelmannii	05
SHRUB LAYER	
Abies lasiocarpa	07
Picea engelmannii	03
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	.5
Antennaria lanata	10
Arnica spp.	.5
Artemisia norvegica	03
Cassiope mertensiana	08
Empetrum nigrum	04
Epilobium angustifolium	02
Erigeron peregrinus	03
Fragaria virginiana	.5
Gaultheria humifusa	03
Pedicularis bracteosa	03
Phyllodoce spp.	20
Picea engelmannii	.5
Pinus albicaulis	.5
Salix barrattiana	.5
Salix glauca	05
Senecio triangularis	01
Sibbaldia procumbens	.5
Trisetum spicatum	.5
Vaccinium scoparium	05
Selaginella selaginoides	03
BRYOID LAYER	
Barbilophozia lycopodioides	05
Cetraria islandica	05
Cladonia coccifera	06
Cladonia ecmocyna	07
Cladonia polydactyla	01
Cladonia pyxidata	03
Dicranum brevifolium	10
Dicranum scoparium	10
Lepraria neglecta	.5
Pachyospora verrucosa	.5
Peltigera aphthosa	03
Polytrichum juniperinum	05
Stereocaulon alpinum	.5
EPIPHYTES	
Bryoria fremontii	.5
Cetraria pinastri	.5
Parmeliopsis ambigua	.5
Usnea spp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

The PL4 Ecosite represents the Upper Subalpine - Alpine ecotone on Till C. In physiographic position, landform surface expression, and vegetation, PL4 resembles the Egypt 4 (EG4) and Larch Valley 2 (LV2) Ecosites. However, in contrast to the Till C of PL4, EG4 occurs on morainal landforms consisting of noncalcareous, medium textured till (Till B), and LV2 occurs on noncalcareous, coarse textured till (Till A). Also both EG4 and LV2 are dominated by Dystric and Sombric rather than Eutric Brunisols. Further LV2 soils have significantly thicker sola. Eutric and Melanic Brunisols of the Tyrrell 1 and 2 (TR1, TR2) Ecosites are morphologically similar but are distinguished because they usually have neutral upper sola with high base saturation. The PL4 Ecosite is differentiated from other Peyto Lake Ecosites by vegetation cover and amount of wet, seepage affected landscape as outlined in Table 277.

PL5 - PEYTO LAKE 5 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, PL5, occurs on morainal blankets and veneers consisting of calcareous, medium textured till (Till C) overlying hummocky and ridged bedrock that form a landscape pattern comprised of about 70% dry (well to moderately well drained, mesic) upland segments and 30% wet (imperfectly to poorly drained, subhygric to subhydric) seepage affected depressions between ridges and hummocks. The upland segment is dominated by Orthic and Eluviated Eutric Brunisols and the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/heather (O10), or subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t.s. The C15 and O10 v.t.s are most abundant but upland segments of some PL5 tracts in southern Banff are dominated by C23. A complex set of genetically related soils, represented by the Orthic Gleysol, Rego Gleysol, Gleyed Ferro-Humic Podzol, and Gleyed Eutric Brunisol subgroups, occur on the wetland segments, usually under the willow/cinquefoil (S8) or willow/timber oatgrass (S11) v.t.s.

Geomorphology

The PL5 Ecosite is typified by morainal blankets and veneers overlying hummocky and ridged bedrock. These moraines consist of calcareous, medium textured till (Till C). Surface veneers of altered, medium textured eolian material (Eolian material B) occur extensively on PL5 tracts of western Banff and southwestern Jasper, sporadically elsewhere. Redeposition of this eolian material in thin veneers of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) has occurred in some depressions. Genetic materials of depressional segments include the till or calcareous, coarse, stratified fluvial material (Fluvial material B) existing as level floodplains or veneers and blankets overlying till. These materials may be overlain by the thin fluviolacustrine and eolian veneers. Occasionally horizontal fens comprised of shallow, moderately decomposed, fen peat may occur in ponded depressions. Colluvium derived from till and/or fractured bedrock is found occasionally on the steepest portions of the landscape. Glacial landforms consisting of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) occur occasionally.

Topographically, PL5 displays a series of subparallel or parallel ridges or irregularly distributed knolls (hummocks) separated by gently sloping depressions. The PL5 Ecosite is usually found on valley floors, valley shoulders, cirque basins, and cols. Slopes commonly range from 5 to 45% overall although slopes of <5% are common on depressional segments. Depressions may be level with abrupt transitions to upland segments or concave and bowl shaped with subtle margins. Morainal veneers dominate on tracts mapped as PL5X. Bedrock outcrops are most common on PL5+R tracts. A few PL5 tracts have linear slopes of lower valley walls straddling long narrow wetlands along the valley floor. Comparatively deep till or ice contact stratified deposits, usually with a hummocky surface form, occur occasionally on failed slopes and valley and cirque floors. Patches of colluvium existing as blankets and veneers occur occasionally on the steepest terrain, particularly below bedrock escarpments.

Soils

Soils of the PL5 Ecosite are distributed in a pattern governed by drainage conditions. The well to moderately well drained upland segments are dominated by Orthic and Eluviated Eutric Brunisols. These soils most often resemble PL1 soils. However, upland soils of several PL5 tracts with subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t.s in southern Banff more resemble PL3 soils and upland soils of PL5 tracts occurring near the upper boundary of the Upper Subalpine, with significant amounts of heather-everlasting (L5) vegetation, resemble PL4 soils. Modally, these Eutric Brunisols have horizons that range from the rudimentary textural horizons associated with weathering of calcareous till to the comparatively distinct Bm and Bf horizons associated with altered, medium textured eolian material (Eolian material B). The accessory soils, Orthic Humo-Ferric Podzols, are genetically related and are most common on PL5 tracts with extensive veneers of Eolian material B. Orthic and Brunisolic Gray Luvisols occur in minor amounts. Eluvial (Ae) hori-

zons are discontinuous across the landscape and are often only weakly expressed in the absence of Eolian material B. In some localities Ae horizons have been destroyed by recent erosional processes such as avalanching, gullying, windthrow of trees, or shallow surface colluviation. Masking of the eluviation process occurs on soils with humus enriched surface horizons under subalpine larch-subalpine fir/grouseberry-everlasting (C23) or heather-everlasting (L5) vegetation. Orthic and Cumulic Regosols occur on steep, colluviating portions of the landscape. Lithic soil phases are associated with the morainal veneers. These dominate on PL5X tracts. The pedons described in Tables 278, 280, and 282 illustrate soils of the upland segment of the PL5 Ecosite.

A variety of genetically related and geomorphically modified soils occur on the imperfectly to poorly drained depressional segments of the PL5 Ecosite. These are best represented by the Orthic Gleysol, Rego Gleysol, Gleyed Ferro-Humic Podzol, and Gleyed Eutric Brunisol subgroups. Strength of gleying is variable, reflecting degree of movement and aeration of seepage waters. The presence of eolian or fluviolacustrine veneers containing volcanic ash material promotes the development of iron, aluminum, and/or humus enriched B and podzolic B horizons (usually Bhf and podzolic Bhf). Recent and continuing fluvial deposition, long periods of saturation, and severe solifluction or cryoturbation retard or destroy pedogenic horizonation. Turbic phases of other soils also occur. Gleyed Eluviated Eutric Brunisols, various gleyed Regosolic soils, and Humic Gleysols occasionally occur in depressions. Terric Mesisols occur occasionally on ponded sites.

A pedon illustrating gleyed Podzolic soils of the wet depressional segment of the PL5 Ecosite is described in Table 284 and shown in Color Plate 54. This pedon has a podzolic Bf horizon with high organic carbon content that has developed in Eolian material B immediately above the till. Podzolic Bhf and Bhf horizons tend to be more common with these geomorphic components. By their textural characteristics, the Ah and AB horizons are developed in altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A). At this site as on many other seepage affected localities this fluviolacustrine material is Eolian material B that has been reworked by slowly moving water.

Vegetation

Vegetation of the PL5 Ecosite is distributed in a pattern governed by drainage conditions. The upland segments are dominated by the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/heather (O10), and subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t.s. The C15 and O10 v.t.s are most abundant and resemble PL1 vegetation cover. Upland segments of several PL5 tracts in southern Banff are dominated by C23, thereby resembling PL3. Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) in northern Jasper and along the Continental Divide, Engelmann spruce-subalpine fir/heather/feathermoss (C34), and, at high elevations, heather-everlasting (L5) are important accessory v.t.s. Modification by snow avalanching (mapped as PL5A) and burning (mapped as PL5B) has occurred in some areas.

A variety of moist to wet Upper Subalpine v.t.s, best represented by willow/cinquefoil (S8) and willow/timber oatgrass (S11), occur on the seepage-affected depressional segments of the PL5 Ecosite. The S8 v.t. tends to be more common on fluvial surfaces, S11 on till surfaces, disregarding the thin eolian and fluviolacustrine veneers. Engelmann spruce-subalpine fir/valerian-fleabane (O9) is a commonly occurring accessory v.t. Occasionally, O10 and C23 extend onto depressions from upland localities. Other v.t.s occuring in minor amounts are arctic willow-cinquefoil (L7), black alpine sedge-everlasting (H2), water sedge-beaked sedge (H11), and fleabane-valerian (H16). A plot representing vegetation of the pedon sample site and illustrating the S11 v.t. on PL5 depressional segments is presented in Table 285 and Plate 145.

Discussion

The PL5 Ecosite encompasses a compound landscape pattern consisting of well to moderately well drained upland segments similar to PL1, occasionally PL3 or PL4, and imperfectly to poorly drained depressional segments similar to the Sphinx 3 (SX3) or Num-Ti-Jah 2 (NT2) Ecosites. The proportion of wet depressions on PL5 tracts commonly ranges from 20 to 40%. Map presentation of PL5 tracts at scales larger than 1:50,000 is invalid because these segments would become mappable as separate Ecosites. The PL5 Ecosite most closely resembles the Egypt 3 (EG3) Ecosite. However, EG3 occurs on morainal landforms consisting of noncalcareous, medium textured till (Till B) rather than Till C and is dominated by acidic soils. The Baker Creek 6 (BK6) Ecosite is the Lower Subalpine counterpart of PL5.

PP - PIPESTONE ECOSECTION

The Pipestone Ecosection occurs on fluvial landforms comprised of calcareous, coarse, stratified fluvial material (Fluvial material B) occurring along streams on valley floors, or on lower slopes and valley floors where streams emerge from higher lands and de-

Table 284 Pedon (Alberta 1978 No. 63) description of a gleyed Humo-Ferric Podzol of wet depressional segments of the PL5 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1970, SUBGROUP: GLEYED HUMO-FERRIC PODZOL. SOIL MAP UNIT: MOTATION: PL5.

LOCATION: MILITARY GRID REF. 11 UNN 3420 2990; NTS MAP AREA 82N 9W.

CLIMATE: 2050 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 5 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VPN=PA8178=VTH=S11=.

SOIL SITE: PARENT MATERIAL 1: FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), UNDIFFERENTIATED, FLUVIOLACUSTRINE, UNDIFFERENTIATED OR UNDETERMINED; PARENT MATERIAL 2: SKELETAL (>35% OF PARTICLES 2-25 CM) AND FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), MORAINAL (TILL), UNDIFFERENTIATED OR UNDETERMINED; LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 3% SIMPLE SLOPE OF CLASS 3 (2-5%), FACING NORTHEAST, SITE AT LOWER SLOPE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,400 M LONG; SOIL MOISTURE AND DRAINAGE: AQUIC, POORLY DRAINED, MODERATELY PERVIOUS, SLOW SURFACE RUNOFF, SEEPAGE PRESENT; NONSTONY; NONROCKY.

SPECIAL NOTES: SSM=NF6102=APM=015-052=PCF=3BR,1CB,1ST(4)4BR,1CB,1ST(5)=LF/M=MB/RM=PARENT MATERIAL 1 CONTAINS AT ITS LOWER BOUNDARY A LAYER(BF HORIZON) OF EOLIAN MATERIAL=

AH: 0 TO 6 CM, RANGE 5 TO 8 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/2; SILTY CLAY LOAM; MODERATE, VERY FINE, GRANULAR STRUCTURE; FRIABLE CONSISTENCE; ABUNDANT, FINE AND VERY FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AB: 6 TO 10 CM, RANGE 3 TO 8 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/3; SILT LOAM; MODERATE, VERY FINE, GRANULAR STRUCTURE; FRIABLE CONSISTENCE; ABUNDANT, FINE AND VERY FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

BF: 10 TO 21 CM, RANGE 8 TO 14 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 4/6; SILT LOAM; WEAK, VERY FINE, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE AND VERY FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

2BCGJ: 21 TO 40 CM, RANGE 15 TO 20 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/4; SILTY CLAY LOAM; COMMON, FINE, DISTINCT, 10YR 5/6 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; FIRM CONSISTENCE; FEW, FINE AND MEDIUM ROOTS; 30% AND 60% AND 30% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2CGJ: 40 TO 105 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/4; GRAVELLY AND GRAVELLY LOAM; COMMON, FINE, DISTINCT, 10YR 5/6 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; FIRM CONSISTENCE; FEW, FINE AND MEDIUM ROOTS; MODERATE EFFERVESCENCE; VERY STRONGLY CALCAREOUS AND VERY STRONGLY CALCAREOUS; 40% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
AH	5.4	10.20		45.7		9.6	2.4	-.1	0.2
AB	5.5	7.40		46.4		6.4	1.9	0.1	0.1
BF	5.5	4.90		43.2		4.7	1.2	0.1	0.1
2BC&J	5.9			15.5		7.4	2.8	0.1	0.2
2C&J	7.1		30.4						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
AH				
AB				
BF	0.3		0.3	
2BC&J				
2C&J				

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS % PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
AH										5		64	31		
AB										5		71	24		
BF										14		78	8		
2BC&J										18		44	38		
2C&J		99	87	64	57					37		42	21		2.18

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AH		75.9	58.8										
AB													
BF													
2BC&J		36.0	15.3										
2C&J		19.7	7.8			16.0	21.0		13.0	1.9		40	18

Table 285 Stand (PA8170) illustrating the willow/-timber oatgrass (S11) v.t. of wet depressional segments of the PL5 Ecosite.

SHRUB LAYER	
Potentilla fruticosa	10
Salix barrattiana	.5
Salix glauca	15
HERB-DWARF SHRUB LAYER	
Aster ciliolatus	03
Danthonia intermedia	45
Deschampsia caespitosa	05
Erythronium grandiflorum	.5
Juncus spp.	.5
Pedicularis bracteosa	03
Pedicularis groenlandica	.5
Phleum alpinum	.5
Poa alpina	.5
Polygonum viviparum	02
Potentilla diversifolia	05
Sibbaldia procumbens	.5
Vaccinium scoparium	.5
BRYOID LAYER	
Barbilophozia lycopodioides	01
Bryoerythrophyllum recurvirostrum	02
Campylium chrysophyllum	05
Ditrichum flexicaule	01
Peltigera canina	.5
Peltigera venosa	.5
Tortella tortuosa	01
Tortula ruralis	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

crease significantly in gradient. The PP Ecosection occurs throughout the Lower Subalpine portion of the Subalpine Ecoregion in Banff and Jasper. Vegetation includes lodgepole pine forest, poplar forest, Engelmann spruce-subalpine fir open and closed forest, white spruce open forest, shrub thicket, shrubby meadow, and herb mat. Soils are dominantly Regosolic.

The Pipestone Ecosection is separated into six Ecosites based mainly on vegetational differences with accompanying minor differences in soil development and landform (Table 286).

PP1 - PIPESTONE 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, PP1, occurs on fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). The PP1 Ecosite is dominated by Orthic and Cumulic Regosols associated with lodgepole pine/buffaloberry/twinflower (C19), lodgepole pine/juniper/bearberry (C3), and lodgepole pine/buffaloberry/showy aster (C6) v.t.s.

Geomorphology

The PP1 Ecosite occurs on fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). Irregular surfaces produced by channeling (Eroded modifier, C.S.S.C. 1978b) are common features of PP1. Landforms of PP1 are considered geomorphologically active and are subject to episodic flooding. This activity produces stratified fluvial materials and soils with little distinct horizon development. Linear slopes ranging from 2 to 45% characterize PP1.

Soils

The PP1 Ecosite is dominated by well drained, calcareous Orthic and Cumulic Regosols. These soils are the result of episodic flooding and sedimentation and include numerous individuals with very thin and/or buried Bm horizons. Accessory soils (Orthic and Eluviated Eutric Brunisols) usually occupy slightly elevated portions of the landscape that are rarely flooded.

A pedon that illustrates a soil of the PP1 Ecosite is described in Table 287. This pedon differs from modal soils by having a Bmbk horizon more than 5 cm thick in the upper 30 cm. Most PP1 soils either lack Bm

Table 286 General features of the Pipestone (PP) Ecosites.

Ecosite	Landform	Soils	Vegetation
PP1	Fluvial material B; fan, apron	Regosolic	lodgepole pine forest
PP2	Fluvial material B; fan, apron	Regosolic	poplar forest
PP3	Fluvial material B; fan, apron	Regosolic	Engelmann spruce-subalpine fir forest
PP4	Glaciofluvial material B; fan, level	Regosolic	herb mat
PP6	Fluvial material B; fan, apron	Regosolic	Engelmann spruce-subalpine fir open forest, white spruce open forest
PP7	Fluvial material B; fan, apron	Regosolic	shrubby meadow, shrub thicket

Table 287 Pedon (Alberta 1975 No. 104) description of a Cumulic Regosol of the PP1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: CUMULIC REGOSOL. SOIL MAP UNIT: NOTATION: PP1.

LOCATION: MILITARY GRID REF. 11 UNS 5760 9490; NTS MAP AREA 82N 6E.

CLIMATE: 1550 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS VERY GOOD RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 10 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: VRMMSS13M.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND STRATIFIED (MINERAL), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), FLUVIAL, MIXED AND SEDIMENTARY; LANDFORM CLASSIFICATION: FLUVIAL, FAN; SLOPE: 1.5% SIMPLE SLOPE OF CLASS 2 (0.5-2%), FACING SOUTHEAST, SITE AT LOWER SLOPE POSITION; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; NONSTONY; NONROCKY.

SPECIAL NOTES: SSN=JTS003*APH=A24783-88*RLU=15*PCF=*MR(7)*THIN (CM) BMB LAYER IN CK HORIZON=CHARCOAL IN CK HORIZON=CARBONATE IN PORES OF BMKB HORIZON=INFILTRATION RATE=11CM/HR=PERCOLATION RATE=3 MIN/CM (MEDIUM) TEXTURED OVERLAY);0.2 MIN/CM (VERY GRAVELLY SANDY LOAM PORTION)*

LF: 3 TO 0 CM, RANGE 1 TO 4 CM; WAVY, ABRUPT HORIZON BOUNDARY.

AHK: 0 TO 6 CM, RANGE 5 TO 7 CM; EXPED MOIST 10YR 5/3; SILT LOAM; WEAK, FINE, GRANULAR STRUCTURE; NONSTICKY, VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; COMMON, FINE PORES; STRONGLY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CK: 6 TO 23 CM, RANGE 15 TO 19 CM; EXPED MOIST 10YR 6/4; SILT LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; SLIGHTLY STICKY, VERY FRIABLE CONSISTENCE; PLENTIFUL, MEDIUM ROOTS; COMMON, FINE PORES; VERY STRONGLY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

BMKB: 23 TO 29 CM, RANGE 5 TO 7 CM; EXPED MOIST 5YR 4/8; SILT LOAM; MODERATE, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; SLIGHTLY STICKY, FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; WEAKLY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CKB1: 29 TO 45 CM, RANGE 14 TO 17 CM; EXPED MOIST 10YR 6/4, EXPED MOIST 10YR 5/4; LOAM; VERY WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; NONSTICKY, VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; STRONGLY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CKB2: 45 TO 52 CM, RANGE 5 TO 9 CM; EXPED MOIST 10YR 5/3; FINE SANDY LOAM; STRUCTURELESS STRUCTURE; NONSTICKY, LOOSE CONSISTENCE; ABUNDANT, FINE ROOTS; MODERATELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CKB3: 52 TO 70 CM; EXPED MOIST 10YR 5/3; VERY GRAVELLY COARSE SANDY LOAM; STRUCTURELESS STRUCTURE; NONSTICKY, LOOSE CONSISTENCE; STRONGLY CALCAREOUS; GRAVELLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	6.5	39.90	16.5						
AHK	7.3	7.30	20.4					0.1	
CK	7.5	2.40	30.5	13.6					
BMKB	7.6	2.10	2.4						
CKB1	7.6	1.40	17.2						
CKB2	7.6	3.40	15.1						
CKB3	7.5		20.7						

SPECIAL ANALYTICAL DATA

HORIZON	INFILTRATION RATE, STEADY STATE (CM/HR)	SATURATED HYDRAULIC CONDUCTIVITY (CM/HR)
LF	11.0	
AHK		
CK		
BMKB		
CKB1		
CKB2		
CKB3		

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AHK										37		51	12	4
CK										14		69	17	4
BMKB										29		54	17	3
CKB1					1	6	13	14	11	47		45	8	2
CKB2					2	9	19	26	15	71		25	4	1
CKB3					28	24	14	4	2	68		30	4	2

horizons or have Bm hoizons less than 5 cm thick. This pedon was sampled on the Pipestone River fan in Banff.

Vegetation

The PP1 Ecosite is dominated by lodgepole pine/buffaloberry/twinflower (C19), lodgepole pine/juniper/bearberry (C3), and lodgepole pine/buffaloberry/showy aster (C6) v.t.s. Modally, C19 occurs more often than C3 and C6 on PP1 tracts. However, a few PP1 tracts are dominated by C3 and C6. The vegetation plot description in Table 288 illustrates the C19 v.t. on PP1 and represents the vegetation at the pedon sample site described above in Table 287. This plot has a lower cover of *Linnaea borealis* in the herb-dwarf shrub layer than is usual for the C19 v.t.

Discussion

Many of the PP1 pedons have thin Bm or Bmb horizons within the upper 50 cm. These Bm and Bmb horizons indicate periods of stability. With longer periods between accretion of fluvial materials, thicker Bm horizons develop resulting in Orthic Eutric Brunisols

Table 288 Stand (KS5138) illustrating the lodgepole pine buffaloberry/twinflower (C19) v.t. of the PP1 Ecosite.

TREE LAYER	
Pinus contorta	80
SHRUB LAYER	
Juniperus communis	01
Lonicera involucrata	.5
Picea glauca	03
Potentilla fruticosa	08
Rosa acicularis	03
Salix glauca	01
Shepherdia canadensis	20
HERB-DWARF SHRUB LAYER	
Achillea millefolium	01
Anemone multifida	.5
Arctostaphylos uva-ursi	08
Arnica cordifolia	02
Aster alpinus	01
Calypso bulbosa	.5
Elymus innovatus	20
Epilobium angustifolium	.5
Fragaria virginiana	08
Galium boreale	01
Gentiana amarella	.5
Hedysarum sulphurescens	05
Linnaea borealis	02
Oryzopsis asperifolia	.5
Pyrola secunda	.5
Senecio indecorus	.5
Trisetum montanum	.5
Vaccinium scoparium	03
BRYOID LAYER	
Brachythecium spp.	05
Dicranum muehlenbeckii	.5
Drepanocladus uncinatus	08
Peltigera aphthosa	.5
Pleurozium schreberi	01
Tortula ruralis	.5
EPIPHYTES	
Alectoria spp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

typical of the Altrude 1 (AL1) Ecosite. The AL1 Ecosite is therefore differentiated from PP1 despite the similar landform and vegetation because the AL1 soils have more distinct horizons reflecting a relatively stable geomorphic environment. The Lower Subalpine PP1 Ecosite also resembles Fireside 1 (FR1) and Verdant 2 (VD2) in landform and vegetation. However, FR1 occurs in the Montane Ecoregion and is separated on that basis and VD2 is differentiated by having more acidic soils developed on noncalcareous, coarse, stratified fluvial material (Fluvial material A) rather than Fluvial material B. The BV1 and BV2 Ecosites are differentiated from PP1 by having more distinct soil horizons and by the more cobbly glaciofluvial materials. Lodgepole pine forests also appear more heterogeneous on PP1 than they do on other Ecosites with more distinct soil horizons. This probably reflects the more active geomorphic environment on PP1.

Tracts mapped as PP1A have 20 to 50% of their area modified by snow avalanching. The avalanche paths usually coincide with the stream channels from which the fluvial fans originate.

PP2 - PIPESTONE 2 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, PP2, occurs on fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). The PP2 Ecosite is dominated by Orthic and Cumulic Regosols associated with balsam poplar/buffaloberry (C17) and aspen/hairy wild rye-peavine (C16) v.t.s. Mapped only in Jasper the majority of PP2 occurs on the lower slopes of the Snake Indian River valley between Blue Creek and the Shale Banks warden cabin.

Geomorphology

The PP2 Ecosite occurs on fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). Irregular surfaces produced by channeling (Eroded modifier, C.S.S.C. 1978b) are common features of PP2. The PP2 Ecosite is considered geomorphologically active and is subject to episodic flooding. This activity produces stratified fluvial materials and soil profiles with no distinct horizonation. Slopes are commonly between 2% and 30%. Other fluvial landforms occurring in minor amounts in PP2 include veneers, blankets, and level plains. Fluvial veneers and blankets usually overlie morainal landforms.

Soils

The PP2 Ecosite is dominated by well to moderately well drained Orthic and Cumulic Regosols. These soils are the result of episodic flooding and sedimentation. Accessory soils (Orthic Eutric Brunisols) usually occupy slightly elevated portions of the landscape that are rarely flooded. Occasionally, gleyed soils occur along the lower margins of fluvial fans and aprons where subsurface water accumulates, resulting in relatively high water tables. The soils of the PP2 Ecosite are very similar to those of the PP3 Ecosite and are well illustrated by Table 290.

Vegetation

The PP2 Ecosite is dominated by the balsam poplar/buffaloberry (C17) and aspen/hairy wild rye-peavine (C16) v.t.s. Modality, C17 occurs more often than C16 on PP2, but a few PP2 tracts are dominated by C16. Lodgepole pine and white spruce v.t.s. are often mixed with balsam poplar and trembling aspen v.t.s on portions of the landscape but are too small to delineate at a map scale of 1:50,000. The vegetation plot description in Table 289 illustrates the C17 v.t. on PP2.

Table 289 Stand (JD9006) illustrating the balsam poplar/buffaloberry (C17) v.t. of the PP2 Ecosite.

TREE LAYER	
Picea glauca	02
Pinus contorta	.5
Populus balsamifera	18
TALL SHRUB LAYER	
Picea glauca	15
Populus balsamifera	01
SHRUB LAYER	
Picea glauca	02
Populus balsamifera	03
Shepherdia canadensis	70
Ribes spp.	.5
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	.5
Achillea millefolium	.5
Arnica cordifolia	01
Elymus innovatus	20
Epilobium angustifolium	.5
Fragaria virginiana	01
Linnaea borealis	05
Mitella nuda	.5
Petasites palmatus	.5
Pyrola secunda	.5
Valeriana sitchensis	01
Viola orbiculata	.5
BRYOID LAYER	
Brachythecium salebrosum	05
Cetraria spp.	.5
Hylocomium splendens	01
Mnium rugicum	.5
Pleurozium schreberi	01
Pylaisiella polyantha	05

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The Lower Subalpine Ecosite, PP2, most resembles the Montane HD1 Ecosite but occurs in a different Ecoregion. The PP2 Ecosite occupies the least areal extent of the Ecosites within the PP Ecosection.

PP3 - PIPESTONE 3 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, PP3, occurs on fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). It is dominated by Orthic and Cumulic Regosols associated with Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t.s.

Geomorphology

The PP3 Ecosite occurs on fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). Irregular surfaces produced by channeling (Eroded modifier, C.S.S.C. 1978b) are common features of PP3. It is considered to be geomorphologically active and is subject to episodic flooding. This activity produces stratified fluvial materials and soils without distinct horizons. Slopes of PP3 commonly range from 2% to 45%. Other fluvial landforms occurring in minor amounts in PP3 include veneers and blankets and level plains. These fluvial veneers and blankets usually overlie morainal landforms.

Soils

Well to moderately well drained, calcareous Orthic and Cumulic Regosols dominate PP3. These soils are the result of episodic flooding and sedimentation and include numerous individuals with very thin and/or buried Bm horizons. Accessory soils (Orthic and Eluviated Eutric Brunisols) usually occupy slightly elevated portions of the landscape that are rarely flooded. A pedon that illustrates a Cumulic Regosol on PP3 is described in Table 290.

Vegetation

The PP3 Ecosite is dominated by the closely related Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) v.t.s. While C13 occurs more frequently than C31 on PP3, a few tracts are dominated by C31, notably in eastern areas of Banff and Jasper. White spruce/buffaloberry/fern moss (C26) and Engelmann spruce/horsetail/feathermoss (C32) are common accessory v.t.s that occur throughout both parks. Engelmann spruce-subalpine fir/false azalea (C14), Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) and Engelmann spruce/hairy wild rye (C33) are other spruce dominated v.t.s that occur in minor amounts on PP3. The vegetation plot description in Table 291 and

Table 290 Pedon (Alberta 1978 No. 92) description of a Cumulic Regosol of the PP3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: CUMULIC REGOSOL. SOIL MAP UNIT: NOTATION: PP3.

LOCATION: MILITARY GRID REF. 11 UBH 850 6569; NTS MAP AREA 83C 2H.

CLIMATE: 1440 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JC8885+VTN=C13+..

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, SANDY, EXTREMELY CALCAREOUS (>40% CACO3), FLUVIAL; LANDFORM CLASSIFICATION: FLUVIAL, FAN; SLOPE: 3% SIMPLE SLOPE OF CLASS 3 (2-5%), FACING SOUTHWEST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,500 M LONG; SOIL MOISTURE AND DRAINAGE: MODERATELY WELL DRAINED, RAPIDLY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; NONSTONY; NONROCKY; PRESENT LAND USE: OUTDOOR RECREATION.

SPECIAL NOTES: SSH=BN8137+APH=010-280+RLU=15+PCF=5GR,3CB(3)6GR,3CB,15T(6)+A+B HORIZON DOMINATED BY AH MATERIAL+.

LF: 6 TO 0 CM, RANGE 4 TO 13 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/2; ABUNDANT, FINE AND COARSE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

BM: 0 TO 2 CM, RANGE 0 TO 5 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/4; SILTY CLAY; VERY WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, FINE AND COARSE ROOTS; MODERATELY POROUS, COMMON, FINE AND MEDIUM PORES; BROKEN, ABRUPT HORIZON BOUNDARY.

C+AK: 2 TO 16 CM, RANGE 8 TO 16 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 3/2; SILT LOAM; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; MODERATELY POROUS, COMMON, VERY FINE AND FINE PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

CK1: 16 TO 29 CM, RANGE 8 TO 17 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/2; VERY FINE SANDY LOAM; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; SLIGHTLY POROUS, FEW, MICRO PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

A+BBK: 29 TO 40 CM, RANGE 7 TO 15 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 3/2, MATRIX MOIST 5YR 3/3; GRAVELLY SILT LOAM; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 50% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK2: 40 TO 100 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/1, MATRIX MOIST 10YR 4/2; VERY GRAVELLY LOAMY SAND; LOOSE CONSISTENCE; VERY FEW, MICRO ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 70% GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	3.8	48.48							
BM	5.0	4.88		37.4		18.1	6.3	-.1	0.3
C+AK	7.4		45.8						
CK1	7.4		76.7						
A+BBK	7.5		44.8						
CK2	7.7		79.3						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2
LF				
BM	0.6		0.1	
C+AK				
CK1				
A+BBK				
CK2				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0 2U CLAY
LF														
BM										1		58	41	
C+AK										12		68	20	
CK1	99	99	99	99			2	27	29	58		39	3	
A+BBK					6	8	6	7	5	34		51	15	
CK2	99	69	39	23	34	34	12	4	2	86		13	1	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	ENGINEERING SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
BM		33.7	21.8										
C+AK													
CK1		8.0	2.5									48	87
A+BBK													
CK2		5.7	1.4									11	82

shown in Plate 146 illustrates the C13 v.t. on PP3 and represents the vegetation at the pedon sample site described above in Table 290.

This vegetation plot was described on Rampart Creek fan in Banff. This fan supports a campground and a borrow pit, and is bisected by the Banff-Jasper highway.

Table 291 Stand (JC8085) illustrating the Engelmann spruce-subalpine fir/feathermoss (C13) v.t. of the PP3 Ecosite.

TREE LAYER	
Picea engelmannii	40
Pinus contorta	20
TALL SHRUB LAYER	
Picea engelmannii	02
SHRUB LAYER	
Picea engelmannii	.5
HERB-DWARF SHRUB LAYER	
Cornus canadensis	.5
Linnaea borealis	.5
Pyrola secunda	.5
Equisetum scirpoides	.5
BRYOID LAYER	
Cladonia arbuscula	.5
Cladonia chlorophaea	.5
Cladonia multiformis	.5
Drepanocladus uncinatus	01
Hylocomium splendens	85
Peltigera aphthosa	04
Peltigera canina	01
Pleurozium schreberi	04
Pohlia nutans	.5
EPIPHYTES	
Alectoria spp.	.5
Hypogymnia physodes	.5
Letharia vulpina	.5
Usnea sorediifera	.5
Usnea subfloridana	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

A few PP3 pedons described have Bm and Bmb horizons that are less than 5 cm thick within the upper 50 cm of the solum. These Bm and Bmb horizons indicate periods of stability. Longer periods without aggradation by fluvial materials allow development of thicker Bm horizons and Orthic Eutric Brunisols to occur, typical of the Altrude 2 (AL2) Ecosite. Therefore, AL2 is differentiated from PP3 despite similar landform and vegetation, by having more distinct soil horizons, reflecting a relatively stable geomorphic environment. The VD1 Ecosite is differentiated from PP3 by having more acidic soils developed on noncalcareous, coarse, stratified fluvial material (Fluvial material A) rather than Fluvial material B. The PP3 Ecosite may also appear similar to Bow Valley 3 (BV3). The cobbly glaciofluvial materials and distinct soil horizons of BV3 differentiate it from PP3 which is characterized by Regosolic fluvial material. Mapped areas designated as PP3A have 20 to 50% of their area modified by snow avalanching. The avalanche paths usually coincide with the stream channels from which the fluvial fans originate. The PP3 Ecosite is the most extensive of the PP Ecosites.

PP4 - PIPESTONE 4 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, PP4, occurs on fans and floodplains comprised of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B). The PP4 Ecosite is characterized by calcareous Orthic Regosols associated with the mesic yellow dryad-willow herb (H8) v.t. It is always found in close proximity to large glaciers or icefields. The majority occurs close to the Continental Divide.

Geomorphology

The PP4 Ecosite occurs on glaciofluvial fans and floodplains comprised of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B). It is characterized by a rapidly aggrading landscape originating from glacier meltwater streams with heavy sediment loads. They produce numerous shallow channels on fans and floodplains that shift frequently, resulting in braided streams. During the summer and periods of above normal temperatures there are diurnal fluctuations of meltwater volume in channels. This activity also produces little or no soil horizon development, coarse, stratified fluvial materials, and fluctuating water tables. Slopes characterizing PP4 are commonly less than 5%.

Soils

The PP4 Ecosite is dominated by rapidly to well drained, highly calcareous Orthic Regosols. These soils are the result of actively aggrading landforms comprised of recent alluvium deposited by glacier meltwater streams and are coarse textured and calcareous to the surface. Minor amounts of Rego Gleysols and Gleyed Regosols are found in depressions in floodplains where the water table is close to the surface. Even though the watertable may be close to the surface during periods when meltwater volume is high, many of the soils show no evidence of mottling, resulting in the Orthic Regosol classification. The lack of mottling may be related to the cold,

Table 292 Pedon (Alberta 1978 No. 20) description of an Orthic Regosol of the PP4 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC REGOSOL. SOIL MAP UNIT: NOTATION: PP4.

LOCATION: MILITARY GRID REF. 11 UPH 7850 9130; NTS MAP AREA 83C 6W.

CLIMATE: 1630 METERS ABOVE MEAN SEA LEVEL. STATION AT COLUMBIA ICEFLD HAS MODERATE RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 7 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=IC6093= VTH=H88=.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, SANDY, EXTREMELY CALCAREOUS (>40% CACO3), SL FLUV, LIMESTONE AND DOLOMITE AND QUARTZITE; LANDFORM CLASSIFICATION: FLUVIAL, SANDY, FAN; SLOPE: 2% SIMPLE SLOPE OF CLASS 2 (0.5-2%), FACING EAST, SITE AT MIDDLE POSITION, 500 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, SEEPAGE ABSENT; PRESENT LAND USE: OUTDOOR RECREATION; HUMUS-FORM: FIBRIMOR AND DECIDUO.

SPECIAL NOTES: SSN=RN80790+APN=810-193+PCF=40R(2-4) 3CB(3-4)=SAMPLE OF LF INCLUDES CURRENT YEARS LEAVES AND SOME COARSE ROOTS=

LF: 3 TO 0 CM, RANGE 1 TO 3 CM; ABUNDANT, FINE AND MEDIUM AND COARSE, RANDOM ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

CK1: 0 TO 18 CM, RANGE 10 TO 18 CM; MATRIX MOIST 10YR 3/2; GRAVELLY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, FINE, RANDOM ROOTS; HIGHLY POROUS, MANY, MEDIUM, RANDOM, INTERSTITIAL PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 30% GRAVELLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

CK2: 18 TO 36 CM, RANGE 18 TO 28 CM; MATRIX MOIST 10YR 3/2; GRAVELLY COARSE SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM, RANDOM ROOTS; HIGHLY POROUS, MANY, COARSE, RANDOM, INTERSTITIAL PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 60% GRAVELLY AND COBBLY COARSE FRAGMENTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

CK3: 36 TO 55 CM; MATRIX MOIST 10YR 3/2; GRAVELLY COARSE SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; VERY FEW, FINE, RANDOM ROOTS; HIGHLY POROUS, MANY, COARSE, RANDOM, INTERSTITIAL PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 50% GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LF	6.4	41.40	
CK1	7.2	0.90	77.4
CK2	7.5	0.70	76.4
CK3	7.4	0.70	79.6

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS													
	% PASSING										% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	78- 2U SILT	50- 2U SILT	2U CLAY	0.2U CLAY
LF														
CK1					9	31	34	11	2	87		13	0	
CK2					20	34	24	12	2	92		8	0	
CK3		99	72	39	23	35	23	6	2	91		9	0	

PHYSICAL DATA

								ENGINEERING				
	MOISTURE STATUS (%)											
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
CK1		2.3	0.9										
CK2													
CK3		2.3	0.6			0.0	0.0					11	SP

organic matter-poor, calcareous soils which provide a poor environment for microbial reduction, or the rapid surface and internal drainage which prevents prolonged periods of saturation. A pedon that illustrates an Orthic Regosol on PP4 is described in Table 292. This pedon was sampled on the Stutfield Glacier creek fan in Jasper.

Vegetation

The PP4 Ecosite is dominated by the mesic yellow dryad-willow herb (H8) v.t. This v.t. covers extensive areas of large river floodplains and glaciofluvial fans that are in close proximity downstream from active melting glaciers. Older portions of PP4 have some evi-

dence of succession to willow and open spruce v.t.s. The vegetation plot description in Table 293 and shown in Plate 147 illustrates the H8 v.t. on PP4 and represents the vegetation at the pedon sample site described above in Table 292.

Table 293 Stand (1C8093) illustrating the yellow dryad-willow herb (H8) v.t. of the PP4 Ecosite.

	HERB-DWARF SHRUB LAYER
Dryas drummondii	45
	BRYOID LAYER
Ditrichum flexicaule	.5
Tortella inclinata	.5
Tortella tortuosa	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

Unvegetated and partially vegetated portions of floodplains mapped as SC (Recent Stream Channel) closely resemble PP4. By definition the PP4 concept may contain up to 50% of SC. A few tracts of land are mapped as PP4+SC (50-80% unvegetated) where it is impossible to delineate vegetated from unvegetated areas due to scale. Hector 4 (HC4) and Hector 2 (HC2) Ecosites are mapped adjacent to PP4 on fluvial floodplains further downstream from active melting glaciers.

PP6 - PIPESTONE 6 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, PP6, occurs on fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). The PP6 Ecosite is characterized by well drained Orthic and Cumulic Regosols associated with Engelmann spruce-subalpine fir/willow/hairy wild rye (O18) and white spruce/juniper/bearberry (O17) v.t.s. It is primarily found in the Front Ranges of both parks.

Geomorphology

The PP6 Ecosite occurs on fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). It is geomorphologically active and is subject to episodic flooding. Flooding produces numerous channels resulting in irregular surfaces (Eroded modifier, C.S.S.C. 1978b) on these tracts of land. It also produces stratified fluvial materials and soils with little or no distinct horizonation. Linear slopes ranging from 2 to 45% characterize PP6. Fluvial floodplains and terraces are landforms that occur in minor amounts and usually have slopes of 2% or less. Other fluvial landforms occurring in small amounts are veneers and blankets usually overlying morainal landforms.

Soils

The PP6 Ecosite is dominated by well drained Orthic and Cumulic Regosols. Episodic flooding and sedimentation prevents horizon development in these soils. Orthic Eutric Brunisols and Orthic Humic Regosols are accessory soils that usually occupy slightly elevated portions of the landscape that are rarely flooded. Minor amounts of Cumulic Humic Regosols occur. Small amounts of gleyed soils occur along the lower margins of fans and aprons and on floodplains where subsurface water causes relatively high water tables. The soil pedon description in Table 294 and shown in Color Plate 55 illustrates the Orthic Regosols of PP6 and was sampled on a fluvial fan south of Mount Tyrrell in Banff. This pedon has a thin Ah horizon, a feature common to many PP6 soils.

Vegetation

The PP6 Ecosite is dominated by the mesic Engelmann spruce-subalpine fir/willow/hairy wild rye (O18) and the subxeric to mesic white spruce/juniper/bearberry (O17) v.t.s. While O18 occurs more often than O17, a few tracts of PP6 are dominated by the O17 v.t. Accessory v.t.s occasionally found on PP6 are white spruce/shrubby cinquefoil/bearberry (O3) and willow/hairy wild rye (S12). The O3 v.t. is closely related to the O17 v.t. and transitional stands occur. The S12 v.t. is often adjacent to and may eventually be succeeded by the O18 v.t. The white spruce/buffaloberry/feathermoss (C37) v.t. occurs in minor amounts on tracts of PP6 in the upper Moosehorn Creek valley in Jasper. The lodgepole pine/juniper/bearberry (C3) v.t. occurs in small amounts on tracts of PP6 in northwestern Banff. A plot illustrating the O18 v.t. on PP6 is described in Table 295 and shown in Plate 148 and represents the vegetation at the pedon sample site described in Table 294.

Discussion

The PP6 Ecosite may appear similar to portions of the Cyclone 1 (CN1) Ecosite where the O18 v.t. occurs. However, CN1 occurs in the Upper Subalpine which separates it from PP6 that occurs in the Lower Subalpine. Patches similar to Pipestone 7 (PP7) may occur in tracts mapped as PP6 but they are too small to be delineated at a map scale of 1:50,000.

Table 294 Pedon (Alberta 1979 No. 85) description of an Orthic Regosol of the PP6 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1979. SUBGROUP: ORTHIC REGOSOL. SOIL MAP UNIT: NOTATION: PP6.

LOCATION: MILITARY GRID REF. 11 UNN 8210 8600; NTS MAP AREA 82O 12H.

CLIMATE: 1860 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 12 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: VMH:[illegible]

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND SANDY, EXTREMELY CALCAREOUS (>40% CACO3), FLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: FLUVIAL, ERODED(CHANNELLED), FAN; SLOPE: 6% SIMPLE SLOPE OF CLASS 4 (4-9%), FACING SOUTHEAST AND SOUTH, SITE AT LOWER SLOPE POSITION, MODERATELY MOUNDED MICROTOPOGRAPHY,300 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; VERY STONY; NONROCKY.

SPECIAL NOTES: [illegible] HORIZON IS BANDED+SURFACE IS TURFY+DATE+AUG.24.1979+

LF: 5 TO 0 CM, RANGE 4 TO 6 CM; MATRIX DRY 10YR 3/1.5; NAVY, CLEAR HORIZON BOUNDARY.

AHK: 0 TO 8 CM, RANGE 3 TO 9 CM; MATRIX DRY 7.5YR 5/2, MATRIX DRY 10YR 5/2; SILT LOAM; MASSIVE STRUCTURE; VERY WEAK, MEDIUM, PLATY SECONDARY STRUCTURE; SLIGHTLY HARD CONSISTENCE; ABUNDANT, MICRO AND VERY FINE AND FINE ROOTS; WEAK EFFERVESCENCE; STRONGLY CALCAREOUS; NAVY, CLEAR HORIZON BOUNDARY.

CK1: 8 TO 12 CM, RANGE 4 TO 9 CM; MATRIX DRY 10YR 8/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SLIGHTLY HARD CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; NAVY, CLEAR HORIZON BOUNDARY.

CK2: 12 TO 38 CM, RANGE 8 TO 23 CM; MATRIX DRY 10YR 8/1.5; COARSE SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; IRREGULAR, ABRUPT HORIZON BOUNDARY.

CK3: 35 TO 62 CM, RANGE 48 TO 85 CM; MATRIX DRY 10YR 8/1.5; GRAVELLY COARSE SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; SOFT CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; IRREGULAR, CLEAR HORIZON BOUNDARY.

CK4: 62 TO 95 CM; MATRIX DRY 10YR 8/1.5; VERY GRAVELLY LOAMY COARSE SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS													
	% PASSING										% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	78-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AHK						1	1	7	15	24		61	15	
CK1					2	3	6	11	17	38		51	11	
CK2					11	19	18	14	8	70		24	6	
CK3		99	63	43	39	26	19	12	10	7	74		19	7
CK4		99	63	48	36	24	21	14	10	6	75		20	5

PHYSICAL DATA

	ENGINEERING							CHEMICAL DATA (SURVEY)			
HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS	HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LF									LF	6.4	38.30	
AHK									AHK	7.1	5.80	17.6
CK1									CK1	7.3	2.20	27.0
CK2									CK2	7.4	0.90	32.5
CK3							11	01	CK3	7.7	0.00	43.7
CK4							11	02	CK4	7.8	0.00	44.1

PP7 - PIPESTONE / ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, PP7, occurs on fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). It is characterized by Orthic and Cumulic Humic Regosols, and Cumulic Regosols associated with the dwarf birch-willow/kobresia (S9) and willow-dwarf birch-shrubby cinquefoil (S10) v.t.a. The PP7 Ecosite is primarily found in the Front Ranges in both parks.

Geomorphology

The PP7 Ecosite occurs on fluvial fans and aprons comprised of calcareous, coarse, stratified fluvial material (Fluvial material B). It is geomorphologically active and is subject to episodic flooding. This activity results in soils with indistinct horizons, stratified fluvial materials, and channeling (Eroded modifier, C.S.S.C. 1978b). Slopes between 2 and 45% characterize PP7. Fluvial floodplains with slopes of 2% or less occur occasionally.

Table 295 Stand (JD9076) illustrating the Engelmann spruce-subalpine fir/willow/hairy wild rye (018) v.t. of the PP6 Ecosite.

TREE LAYER	
Picea engelmannii	20
TALL SHRUB LAYER	
Picea engelmannii	02
SHRUB LAYER	
Picea engelmannii	.5
Potentilla fruticosa	.5
Rosa acicularis	.5
Salix glauca	25
Shepherdia canadensis	01
HERB-DWARF SHRUB LAYER	
Achillea millefolium	.5
Arctostaphylos uva-ursi	05
Astragalus alpinus	02
Astragalus occidentalis	03
Campanula rotundifolia	.5
Carex concinna	.5
Delphinium glaucum	.5
Elymus innovatus	65
Epilobium angustifolium	05
Festuca saximontana	.5
Festuca scabrella	.5
Fragaria virginiana	01
Gentiana propinqua	01
Hedysarum alpinum	02
Poa spp.	05
Senecio lugens	01
Equisetum scirpoides	02
BRYOID LAYER	
Aulacomnium palustre	02
Cetraria ericetorum	.5
Cladonia pyxidata	.5
Dicranum acutifolium	.5
Drepanocladus uncinatus	05
Peltigera aphthosa	01
Peltigera canina	03
Pleurozium schreberi	25
Pohlia nutans	.5
Thuidium abietinum	.5
Tortula ruralis	02
EPIPHYTES	
Bryoria lanestris	.5
Parmelia subelegantula	.5
Parmelia sulcata	.5
Usnea alpina	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Soils

The PP7 Ecosite is dominated by well drained Orthic and Cumulic Humic Regosols and Cumulic Regosols that reflect the incorporation of humus and modifications by fluvial accretion. Surfaces of Orthic and Cumulic Humic Regosols have remained stable long enough for development of relatively thick Ah horizons. Organo-mineral (Ah) horizon development has been interrupted by episodic flooding and fluvial aggradation in Cumulic Regosols. Orthic Eutric Brunisols are accessory soils that usually occupy slightly elevated portions of the landscape that are rarely flooded. However, Orthic Regosols are accessory soils that usually occupy more active portions of the landscape and are frequently flooded. Minor amounts of gleyed soils occur where water tables are high along the lower margins of fans and aprons and on floodplains. A pedon illustrating Orthic Humic Regosols on PP7 is described in Table 296 and shown in Color Plate 56. This pedon was sampled on a fluvial fan at the east end of Southesk Lake in Jasper.

Vegetation

The PP7 Ecosite is dominated by the subxeric dwarf birch-willow/kobresia (S9) and willow-dwarf birch-shrubby cinquefoil (S10) v.t.s. While S9 occurs more often than S10, a few tracts of PP7 are dominated by S10. The willow/timber oatgrass (S11) is an accessory v.t. on PP7 in sites where soil is imperfectly to moderately well drained. Hairy wild rye-junegrass-bearberry (H14) is also an accessory v.t. usually associated with steeper slopes on rapidly to well drained sites. Minor amounts of the willow/hairy wild rye (S12) v.t. occur in patches on a few tracts of PP7.

A vegetation plot described in Table 297 and shown in Plate 57 illustrates the S9 v.t. on PP7 and represents the vegetation at the pedon sample site described above in Table 296.

Discussion

The PP7 Ecosite most resembles the Hector 4 (HC4) and Cyclone 1 (CN1) Ecosites. The HC4 Ecosite is differentiated from PP7 by having imperfectly to poorly rather than well drained soils occurring on fluvial floodplains rather than fans. The CN1 Ecosite is the Upper Subalpine counterpart of PP7.

PR - PANORAMA RIDGE ECOSECTION

The Panorama Ridge Ecosection is one of the most extensive in Banff and Jasper and encompasses glacial landforms comprised of calcareous glacial materials throughout the Lower Subalpine portion of the Subalpine Ecoregion. It occurs primarily on valley walls and floors including benchlands on broad valley floors and is associated with calcareous bedrock strata.

The dominant soils, Eutric Brunisols, often exhibit luvisolic tendencies asociated with weathering of calcareous glacial deposits under well drained, mesic conditions within the Lower Subalpine. Genetically related Brunisolic Gray Luvisols are the subdominant

Table 296 Pedon (Alberta 1979 No. 55) description of an Orthic Humic Regosol of the PP7 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC HUMIC REGOSOL. SOIL MAP UNIT: NOTATION: PP7, ASSOCIATED SOILS: CUR.

LOCATION: MILITARY GRID REF. 11 UNJ 0900 3230; NTS MAP AREA 83C 11=.

CLIMATE: 1850 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 7 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: VPN=PA9117=VTH=S9=.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND STRATIFIED (MINERAL), EXTREMELY CALCAREOUS (>40% CACO3), FLUVIAL, SILTSTONE AND MUDSTONE AND LIMESTONE; LANDFORM CLASSIFICATION: FLUVIAL, GRAVELLY AND SANDY, FAN; SLOPE: 3% SLOPE OF CLASS 3 (2-5%), FACING SOUTH, SITE AT LOWER SLOPE POSITION, LEVEL MICROTOPOGRAPHY,300 M LONG; SOIL MOISTURE AND DRAINAGE: SUBHUMID, RAPIDLY DRAINED, RAPIDLY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; SLIGHTLY STONY; NONROCKY; HUMUS-FORM: MULL AND FINE, LOAMY, CALCAREOUS.

SPECIAL NOTES: SSN=PS9168=APN=010-091=PCP=30R,3CB(3)=DISCONTINUOUS AHKB=DATE=AUG.26,1979=

AHK: 0 TO 10 CM, RANGE 0 TO 11 CM; HORIZON MOIST; CRUSHED MOIST 10YR 2/1; SILTY CLAY LOAM; WEAK, VERY FINE TO FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE AND MEDIUM, HORIZONTAL, INPED AND EXPED ROOTS; MODERATELY POROUS; MODERATE EFFERVESCENCE; MODERATELY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

CK1: 10 TO 42 CM, RANGE 23 TO 35 CM; HORIZON DRY; CRUSHED DRY 10YR 5/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT CONSISTENCE; FEW, FINE, OBLIQUE ROOTS; MODERATELY POROUS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

CK2: 42 TO 100 CM; HORIZON MOIST; CRUSHED MOIST 10YR 3/2; GRAVELLY SANDY LOAM; STRUCTUPELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, FINE, VERTICAL ROOTS; HIGHLY POROUS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 40% GRAVELLY AND COBBLY COARSE FRAGMENTS.

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS														
	X PASSING				X OF SAMPLE										
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
AHK					1	1	2	5	8	17		52	31		
CK1	99	99	99	95		1	1	4	11	17		69	14		
CK2	99	77	44	36	14	10	12	17	11	64		29	7		1.20

PHYSICAL DATA

	ENGINEERING								CHEMICAL DATA (SURVEY)			
HORIZON	ATTERBURG PLASTIC LIMIT (X)	ATTERBURG LIQUID LIMIT (X)	SHRINKAGE LIMIT (X)	OPT MOIST CONTENT (X)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS	HORIZON	PH 1	ORG C (X)	CALC CARB EQU.X
AHK									AHK	7.0	12.00	6.7
CK1	22.0	26.0					A0	09	CK1	7.5		47.1
CK2							11	03	CK2	7.4		68.6

Table 297 Stand (PA9117) illustrating the dwarf birch-willow/kobresia (S9) v.t. of the PP7 Ecosite.

SHRUB LAYER	
Betula glandulosa	20
Salix glauca	20
HERB-DWARF SHRUB LAYER	
Achillea millefolium	02
Agoseris glauca	.5
Androsace chamaejasme	.5
Anemone parviflora	.5
Antennaria pulcherrima	01
Carex scirpoidea	.5
Danthonia intermedia	10
Delphinium glaucum	01
Deschampsia caespitosa	.5
Elymus innovatus	05
Fragaria virginiana	05
Gentiana amarella	01
Hedysarum alpinum	.5
Kobresia myosuroides	45
Oxytropis deflexa	01
Poa alpina	.5
Rubus acaulis	.5
Valeriana sitchensis	.5
BRYOID LAYER	
Bryoerythrophyllum recurvirostrum	.5
Bryum caespiticium	.5
Caloplaca jungermanniae	.5
Cetraria ericetorum	.5
Cladonia pyxidata	.5
Peltigera rufescens	.5
Rinodina roscida	.5
Thuidium abietinum	.5
Tortella fragilis	.5
Tortella tortuosa	.5
Tortula ruralis	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

soils. The dominant vegetation, lodgepole pine forest, reflects complex fire and successional histories. A variety of component factors including genetic material differences, episodic seepage giving gleyed soil subgroups on failed slopes, a northerly - southerly aspect landscape patter, and specific vegetational differences separate the five Panorama Ridge Ecosites as outlined in Table 298. Fig. 49 shows the landscape relationship of four Panorama Ridge Ecosites.

PR1 - PANORAMA RIDGE 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, PR1, occurs on morainal blankets consisting of calcareous, medium textured till (Till C) overlying inclined bedrock on valley walls. The dominant soils, Orthic and Eluviated Eutric Brunisols, frequently display luvisolic tendencies associated with the weathering of calcareous till. Genetically related Brunisolic Gray Luvisols are subdominant. The dominant v.t.s, lodgepole pine/false azalea/grouseberry (C20), lodgepole pine/feathermoss (C11), and lodgepole pine/Labrador tea (C29), are seral to the Engelmann spruce - subalpine fir types that dominate the Bryant (BY) Ecosection.

The PR1 Ecosite occurs frequently near the Continental Divide, occupying northerly and southerly aspects. East of the Divide it becomes increasingly restricted to northerly aspects.

Geomorphology

The PR1 Ecosite is typified by morainal blankets consisting of calcareous, medium textured till (Till C) overlying inclined bedrock. Surface veneers of altered, medium textured eolian material (Eolian material B) occur, especially in western Banff and southwestern Jasper, but tend to be shallower and less extensive overall than on the Bryant 1 (BY1) Ecosite. Greater erosion following fire may be a contributing factor. Colluvium derived from till and/or fractured bedrock is found occasionally on the steepest portions of the landscape. Calcareous, variably textured ice contact stratified drift occurs rarely in tracts mapped as PR1.

Topographically, the PR1 Ecosite displays long, linear slopes consisting of till mantling the inclined bedrock that forms valley walls. Slopes normally range from 15 to 70% and are often dissected by subparallel gullies oriented perpendicular to the contour. Small fluvial fans and aprons emanating from gully mouths along valley bottoms or other major slope breaks may be included in PR1 tracts. Tracts mapped as PR1 situated along valley bottoms (including valley floor benchlands), at valley confluences, on valley shoulders, and occasionally on failed slopes, often display morainal landforms with irregular surfaces and complex topography (5-45% slopes). These landforms include morainal blankets and veneers overlying ridged and hummocky bedrock and the relatively deep till of hummocky moraines. Morainal veneers, also occasionally found on inclined slopes, dominate tracts mapped as PR1X. Bedrock outcrops occasionally on all types of terrain and are common on tracts mapped as PR1+R. Patches of colluvium existing as blankets and veneers occur occasionally on the steepest terrain, particularly below bedrock escarpments.

Soils

Soils of the PR1 Ecosite are distributed in a pattern reflecting degree of luvisolic and eluvial (Ae) horizon development. Orthic and Eluviated Eutric Brunisols are dominant, Brunisolic Gray Luvisols subdominant. These well drained soils have weak textural B horizons, some with sufficient pedogenic clay film

Table 298 General features of the Panorama Ridge (PR) Ecosites.

Ecosite	Landform	Soils	Vegetation
PR1	Till C; blanket	Eutric Brunisol > Gray Luvisol	lodgepole pine/ false azalea, lodgepole pine/feathermoss, lodgepole pine/Labrador tea
PR2	Till C; blanket	Eutric Brunisol > Gray Luvisol	lodgepole pine/buffaloberry
PR3	Till C; blanket, hummocky	gleyed Brunisolic > gleyed Luvisolic	lodgepole pine forest
PR4	Till C, Ice Contact Stratified Drift B; inclined	Northerly: Brunisolic Southerly: Brunisolic > Luvisolic, Regosolic	Northerly: Engelmann spruce-subalpine fir forest Southerly: lodgepole pine forest
PR6	Ice Contact Stratified Drift B; blanket, hummocky	Eutric Brunisol > Gray Luvisol	lodgepole pine forest

Figure 49 Landscape schematic showing the relationship of the Panorama Ridge (PR) Ecosites to other Ecosites.

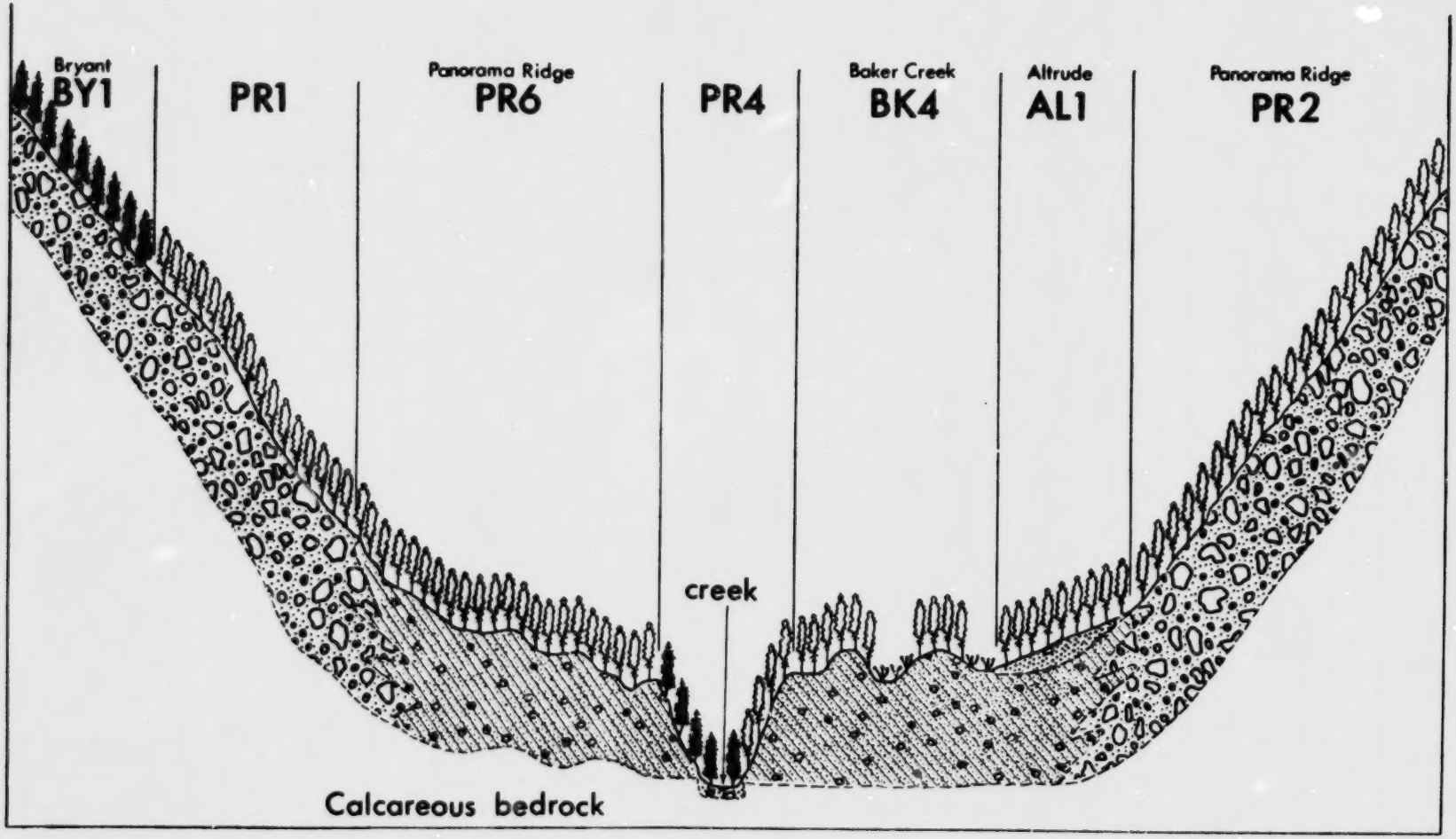


Table 299 Pedon (Alberta 1979 No. 63) description of an Eluviated Eutric Brunisol of the PR1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC HUMIC REGOSOL. SOIL MAP UNIT: NOTATION: PP7.

LOCATION: MILITARY GRID REF. 11 UMJ 8900 3230; NTS MAP AREA 83C 11*.

CLIMATE: 1850 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 7 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: VPN=PA9117*VTN=S9*.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND STRATIFIED (MINERAL), EXTREMELY CALCAREOUS (>40% CACO3), FLUVIAL, SILTSTONE AND MUDSTONE AND LIMESTONE; LANDFORM CLASSIFICATION: FLUVIAL, GRAVELLY AND SANDY, FAN; SLOPE: 3% SLOPE OF CLASS 3 (2-5%), FACING SOUTH, SITE AT LOWER SLOPE POSITION, LEVEL MICROTOPOGRAPHY,300 M LONG; SOIL MOISTURE AND DRAINAGE: SUBHUMID, RAPIDLY DRAINED, RAPIDLY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; SLIGHTLY STONY; NONROCKY; HUMUS-FORM: MULL AND FINE, LOAMY, CALCAREOUS.

SPECIAL NOTES: SSN=PS9165*APN=010-091*PCF=3GR,3CB(3)*DISCONTINUOUS AHKB*DATE=AUG.26.1979*

AHK: 0 TO 10 CM, RANGE 8 TO 11 CM; HORIZON MOIST; CRUSHED MOIST 10YR 2/1; SILTY CLAY LOAM; WEAK, VERY FINE TO FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE AND MEDIUM, HORIZONTAL, INPED AND EXPED ROOTS; MODERATELY POROUS; MODERATE EFFERVESCENCE; MODERATELY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

CK1: 10 TO 42 CM, RANGE 23 TO 35 CM; HORIZON DRY; CRUSHED DRY 10YR 5/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT CONSISTENCE; FEW, FINE, OBLIQUE ROOTS; MODERATELY POROUS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

CK2: 42 TO 100 CM; HORIZON MOIST; CRUSHED MOIST 10YR 3/2; GRAVELLY SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, FINE, VERTICAL ROOTS; HIGHLY POROUS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 40% GRAVELLY AND COBBLY COARSE FRAGMENTS.

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS													
	% PASSING				% OF SAMPLE									
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
AHK					1	1	2	5	8	17		52	31		
CK1	99	99	99	95		1	1	4	11	17		69	14		
CK2	99	77	44	36	14	10	12	17	11	64		29	7		1.89

PHYSICAL DATA

	ENGINEERING							CHEMICAL DATA (SURVEY)			
HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS	HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
AHK									AHK	7.0	12.00	6.7
CK1	22.0	26.8					40	09	CK1	7.5		47.1
CK2							11	03	CK2	7.6		60.6

development to be Bt horizons, occurring at or near the till-eolian material interface. Iron, aluminum, and humus enriched Bm horizons, developed in the Eolian material B veneers, often overlie the textural B horizons. Soils with Bf and podzolic Bf horizons developed in the eolian material also occur occasionally. Overall, the expression of luvisolic tendencies in PR1 soils is stronger than in soils of the Bryant (BY) Ecosites but slightly weaker than in PR2 soils. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly expressed in the absence of Eolian material B. In some localities, Ae horizons have been destroyed by recent surface disturbance such as avalanching, gullying, windthrow of trees, or shallow surface colluviation. Some gullies and depressional localities contain seeps with associated wet soils. Orthic and Cumulic Regosols often occur on steep, colluviating portions of the landscape. Lithic soil phases are not common, except on tracts mapped as PR1X where they dominate.

A pedon illustrating Eluviated Eutric Brunisols of the PR1 Ecosite is described in Table 299 and is shown in Color Plate 57. This pedon exhibits weak luvisolic tendencies in its Bm horizons and has a very thin eolian veneer.

Vegetation

The PR1 Ecosite is dominated by the lodgepole pine/feathermoss (C11), lodgepole pine/false azalea/grouseberry (C20), and lodgepole pine/Labrador tea (C29) v.t.s. Except for the dominance of *Pinus contorta* rather than *Picea engelmannii* in the tree layer, these types resemble the successionally mature Engelmann spruce - subalpine fir v.t.s (C13, C14, C21, C30) that characterize the Bryant (BY) Ecosection. Overall, C20 is more abundant than either C11 or C29 but several PR1 tracts in central and eastern regions of both parks are dominated by C11 or C29. Small, unburned remnant stands of Engelmann spruce - subalpine fir, usually the Engelmann spruce-subalpine fir/feathermoss

(C13) or Engelmann spruce-subalpine fir/false azalea (C14) v.t.s occur occasionally on PR1 tracts. Moist to wet Lower Subalpine v.t.s are associated with seeps. Modification by snow avalanching and recent fires has occurred in some areas.

A stand representing vegetation of the pedon sample site described above (Table 299) and illustrating the C20 v.t. of the PR1 Ecosite is described in Table 300. This stand occurs near the northern limit of *Vaccinium scoparium*.

Discussion

Conceptually, PR1 spans a soil development - vegetation succession gap between the Bryant (BY1 and BY2) and Panorama Ridge 2 (PR2) Ecosites. Specific vegetation differences separate PR1 from PR2, soil drainage reflecting seepage conditions separates PR1 from PR3 (Table 298). The Moraine Lake 2 (ML2) and Cavell 4 (CA4) Ecosites resemble PR1 physiographic position, landform surface expression and vegetation cover. However, in contrast to the Till C characterizing PR1, ML2 occurs on morainal landforms consisting of noncalcareous, coarse textured till (Till A), and CA4 occurs on noncalcareous, medium textured till (Till B). Also, both ML2 and CA4 are dominated by Dystric rather than Eutric Brunisols. The ML2 soils have significantly thicker sola than soils characterizing PR1.

PR2 - PANORAMA RIDGE 2 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, PR2, occurs on morainal blankets consisting of calcareous, medium textured till (Till C) overlying inclined bedrock on valley walls. The dominant soils, Orthic and Eluviated Eutric Brunisols, frequently display luvisolic tendencies associated with weathering of calcareous till. Genetically related Brunisolic Gray Luvisols are subdominant. Vegetation cover is dominated by the closely related lodgepole pine/buffaloberry/showy aster (C6), lodgepole pine/buffaloberry/grouseberry (C18), and lodgepole pine/buffaloberry/twinflower (C19) v.t.s. that reflect the extensive fires that have occurred in the Lower Subalpine.

The PR2 Ecosite is mainly restricted to southerly aspects near the Continental Divide but east of the Divide it becomes increasingly common on all aspects. In addition, PR2 is more extensive in central and eastern regions of both parks.

Geomorphology

The PR2 Ecosite is typified by morainal blankets consisting of calcareous, medium textured till (Till C) overlying inclined bedrock. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically and are quite thin. Where present, the eolian material influences soil development. Erosion following fire may be a

Table 300 Stand (SJ9128) illustrating the lodgepole pine/false azalea/grouseberry (C20) v.t. of the PR1 Ecosite.

TREE LAYER	
Abies lasiocarpa	.5
Picea glauca	07
Pinus contorta	35
TALL SHRUB LAYER	
Picea glauca	07
Pinus contorta	03
SHRUB LAYER	
Abies lasiocarpa	02
Juniperus communis	.5
Ledum groenlandicum	02
Menziesia glabella	55
Picea glauca	08
Pinus contorta	05
Ribes oxyacanthoides	.5
Salix glauca	01
Shepherdia canadensis	01
HERB-DWARF SHRUB LAYER	
Arnica cordifolia	02
Cornus canadensis	02
Elymus innovatus	.5
Epilobium angustifolium	.5
Pyrola secunda	.5
Vaccinium caespitosum	.5
Vaccinium membranaceum	04
Vaccinium scoparium	02
Equisetum scirpoides	01
Lycopodium annotinum	.5
BRYOID LAYER	
Aulacomnium palustre	.5
Brachythecium salebrosum	.5
Ceratodon purpureus	.5
Cladonia mitis	.5
Cladonia cenotea	.5
Cladonia cornuta	.5
Cladonia crispata	.5
Cladonia deformis	.5
Cladonia gonecha	.5
Cladonia multiformis	.5
Dicranum scoparium	.5
Drepanocladus uncinatus	.5
Hylocomium splendens	10
Peltigera aphthosa	.5
Peltigera canina	.5
Pleurozium schreberi	35
Ptilium crista-castrensis	.5
Stereocaulon tomentosum	.5
Barbilophozia lycopodioides	01
Ptilidium pulcherrimum	.5
EPIPHYTES	
Bryoria lanestris	.5
Cetraria merrillii	.5
Cetraria pinastri	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5
Usnea spp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

contributing factor to the absence or thinness of this material. Colluvium derived from till and/or fractured bedrock is found occasionally on the steepest portions of the landscape. Calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) occurs rarely.

Topographically, the PR2 Ecosite displays long, linear slopes consisting of till mantling the inclined bedrock that forms valley walls. Slopes normally range from 15 to 70% and are often dissected by subparallel gullies oriented perpendicular to the contour. Small fluvial fans and aprons emanating from gully mouths along valley bottoms or other major slope breaks may be included in PR2 tracts. Tracts mapped as PR2 situated along valley bottoms (including valley floor benchlands), at valley confluences, on valley shoulders, and on failed slopes, often display morainal landforms with irregular surfaces and complex topography (5-45% slopes). These landforms include morainal blankets and veneers overlying ridged and hummocky bedrock and the relatively deep till of hummocky moraines. Morainal veneers, also occasionally found on inclined slopes, dominate tracts mapped as PR2X. Bedrock outcrops occur occasionally on all types of terrain and are common on tracts mapped as PR2+R. Patches of colluvium existing as blankets and veneers occur occasionally on the steepest terrain, particularly below bedrock escarpments.

Soils

Soils of the PR2 Ecosite are distributed in a pattern reflecting degree of luvisolic and eluvial (Ae) horizon development. Orthic and Eluviated Eutric Brunisols are dominant, Brunisolic Gray Luvisols subdominant. These well drained soils have weak textural B horizons, some with sufficient pedogenic clay film development to be Bt horizons, occurring at or near the till-eolian material inerface. Iron, aluminum, and humus enriched Bm horizons developed in the Eolian material B veneers may overlie the textural B horizons, particularly in the Luvisolic soils. Genetically related Orthic Gray Luvisols are accessory soils and occur sporadically where the eolian veneer is absent. Overall, the expression of luvisolic tendencies in PR2 soils is slightly stronger than in PR1 soils. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly expressed in the absence of Eolian material B. In some localities, Ae horizons have been destroyed by recent surface modification such as avalanching, gullying, windthrow of trees, or shallow surface colluviation. Orthic Eutric Brunisols with thin Bmk horizons and Orthic Regosols occur locally on more severely eroded portions of the landscape. These soils resemble the Goat 1 (GT1) Ecosite soils. Seeps occur rarely. Lithic soil phases are not common except on tracts mapped as PR2X where they dominate.

A pedon illustrating Eluviated Eutric Brunisols of the PR2 Ecosite is described in Table 301 and shown in Color Plate 58. The sample site is shown in Plate 149. The horizons of this pedon appear to be developed in a mixture of eolian and till material. The B horizon illustrates well the luvisolic tendencies in PR2 soils.

Vegetation

The closely related lodgepole pine/buffaloberry/showy aster (C6), lodgepole pine/buffaloberry/grouseberry (C18), and lodgepole pine/buffaloberry/twinflower (C19) v.t.s dominate the PR2 Ecosite. Factors affecting distribution of these types are not fully understood, although C6 is confined to relatively low elevations possibly on slightly drier sites. One or more of these types can be dominant or codominant on PR2 tracts. Lodgepole pine/juniper/bearberry (C3) and lodgepole pine/green alder/feathermoss (C10) are two important accessory v.t.s. The C3 v.t. is common on subxeric to mesic, well to rapidly drained, steeply sloping sites. An open canopied variant of C3, resembling the Goat 1 (GT1) Ecosite vegetation, occurs locally on eroding and recently eroded sites with Regosolic and weakly developed Brunisolic soils. A C3 variant that has significant amounts of Engelmann spruce is abundant on some tracts near Banff's eastern boundary. The C10 v.t. occurs primarily on northerly aspects at low elevations adjacent to Montane areas and is most often found in northeastern Jasper. Patches of lodgepole pine/feathermoss (C11), Engelmann spruce-subalpine fir/feathermoss (C13), lodgepole pine/false azalea/grouseberry (C20), and lodgepole pine/Labrador tea (C29) occur in minor amounts. Modification by avalanching and recent fires has occurred in some areas. Moist to wet Lower Subalpine v.t.s occur rarely in tracts mapped as PR2.

A stand illustrating the C19 v.t. of the PR2 Ecosite is described in Table 302. This stand is located about 1 km downslope (200 m lower in elevation) from the pedon sample site described above (Table 301).

Discussion

The PR2 Ecosite is the most extensive of the Panorama Ridge Ecosites and is one of the most extensive Ecosites in the study area. Specific vegetation differences separate PR1 from PR2, soil drainage reflecting seepage separates PR2 from PR3 (Table 298). The Moraine Lake 2 (ML2) and Cavell 4 (CA4) Ecosites resemble PR2 in physiographic position, landform surface expression, and vegetation cover. However, rather than the Till C

Table 301 Pedon (Alberta 1979 No. 43) description of an Eluviated Eutric Brunisol of the PR2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: PR2.

LOCATION: MILITARY GRID REF. 11 UPK 2115 250; NTS MAP AREA 83E 6E.

CLIMATE: 1630 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 9 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: VMN=LC9170+VMH=C18=.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL), SEDIMENTARY; LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 31% SIMPLE SLOPE OF CLASS 7 (31-45%), FACING SOUTH. SITE AT UPPER SLOPE POSITION. MODERATELY MOUNDED MICROTOPOGRAPHY,500 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY.

SPECIAL NOTES: SSN=SC9064+APH=018-134+PCP=26R,2CB(2-3)26R,1CB(4)36R,2CB(5-8)+EOLIAN SURFICIAL DEPOSIT+LFH=MB/RI+

LF: 4 TO 0 CM, RANGE 3 TO 5 CM; MATRIX MOIST 7.5YR 3/2; FEW, FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE1: 0 TO 4 CM, RANGE 3 TO 5 CM; MATRIX MOIST 10YR 6/3; SILT LOAM; WEAK, FINE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; FEW, VERY FINE PORES; 20% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

AE2: 4 TO 8 CM, RANGE 3 TO 6 CM; MATRIX MOIST 10YR 7/4; SILT LOAM; WEAK, COARSE, PLATY STRUCTURE; WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; MANY, VERY FINE PORES; 20% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

BTJ: 8 TO 28 CM, RANGE 17 TO 23 CM; MATRIX MOIST 7.5YR 5/6; CLAY LOAM; MODERATE, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; FEW, VERY FINE PORES; FEW, VERY THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; 10% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BCK: 28 TO 39 CM, RANGE 7 TO 11 CM; MATRIX MOIST 10YR 3/3; LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MICRO ROOTS; VERY FEW, VERY FINE PORES; 30% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

CK1: 39 TO 48 CM, RANGE 8 TO 12 CM; MATRIX MOIST 10YR 5/3; LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, MICRO ROOTS; FEW, VERY FINE PORES; 30% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

CK2: 48 TO 70 CM, RANGE 20 TO 26 CM; MATRIX MOIST 10YR 4/2; LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, MICRO ROOTS; FEW, VERY FINE PORES; 30% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, DIFFUSE HORIZON BOUNDARY.

CK3: 70 TO 103 CM; MATRIX MOIST 10YR 5/3; FINE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, MICRO ROOTS; FEW, VERY FINE PORES; 30% GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.5	43.40		7.4		3.8	0.7	.0.1	0.1
AE1	4.8	1.20		7.4		4.2	0.9	0.1	0.1
AE2	4.9	1.10		17.2		16.6	4.6	-.1	0.2
BTJ	6.3	1.50							
BCK	7.1		32.3						
CK1	7.3		40.7						
CK2	7.4		33.8						
CK3	7.6		41.1						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE1				
AE2				
BTJ	0.1		-.1	
BCK				
CK1				
CK2				
CK3				

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	X PASSING .75" SIEVE	X PASSING NO.4 SIEVE	X PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	X OF SAMPLE 50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF															
AE1					2	4	7	12	10	35		41	4		1.30
AE2					2	4	8	14	14	42		51	7		
BTJ					2	3	6	9	8	28		38	34		1.40
BCK					5	7	10	13	9	44		46	10		
CK1					8	7	7	10	7	39		47	14		
CK2					4	9	12	15	9	51		41	8		
CK3		99	69	57	54	5	11	10	13	9	48		44	6		2.10

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AE1								
AE2								
BTJ								
BCK								
CK1								
CK2								
CK3							24	87

Table 302 Stand (LC9023) illustrating the lodgepole pine/buffaloberry/twinflower (C19) v.t. of the PR2 Ecosite.

TREE LAYER	
Picea glauca	10
Pinus contorta	35
TALL SHRUB LAYER	
Picea glauca	05
Pinus contorta	10
SHRUB LAYER	
Alnus crispa	01
Ledum groenlandicum	03
Picea glauca	01
Rosa acicularis	05
Shepherdia canadensis	45
Viburnum edule	01
Salix spp.	01
HERB-DWARF SHRUB LAYER	
Arctostaphylos uva-ursi	02
Arnica cordifolia	03
Cornus canadensis	10
Elymus innovatus	03
Fragaria virginiana	.5
Ledum groenlandicum	05
Linnaea borealis	12
Picea glauca	01
Pyrola secunda	02
Spiraea lucida	02
Vaccinium caespitosum	08
Viburnum edule	01
BRYOID LAYER	
Cladonia bacillaris	.5
Cladonia cornuta	.5
Cladonia cristatella	.5
Cladonia ecmocyna	.5
Cladonia gonecha	01
Cladonia multiformis	.5
Dicranum polysetum	.5
Drepanocladus uncinatus	02
Hylocomium splendens	40
Lophozia spp.	.5
Peltigera aphthosa	04
Pleurozium schreberi	10
Pohlia nutans	01
Ptilium crista-castrensis	15
Barbilophozia lycopodioides	01
EPIPHYTES	
Bryoria fuscescens	.5
Cetraria pinastri	.5
Parmeliopsis ambigua	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

of PR2, ML2 occurs on morainal landforms consisting of noncalcareous, coarse textured till (Till A), and CA4 occurs on noncalcareous, medium textured till (Till B). Further, both ML2 and CA4 are dominated by Dystric rather than Eutric Brunisols. The ML2 soils also have significantly thicker sola. The PR2 Ecosite resembles (genetic material, soils, and vegetation cover) the upland segment of BK1 but the dry-wet pattern of BK1 distinguishes it from PR2. Several of the more steeply sloping PR2 tracts contain small areas of actively eroding or recently eroded localities that resemble the Goat 1 (GT1) Ecosite. These areas are too small to be delineated at a map scale of 1:50,000.

PR3 - PANORAMA RIDGE 3 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, PR3, occurs on morainal landforms consisting predominantly of the low lime phase of calcareous, medium textured till (Till C). These moraines exist as blankets overlying hummocky and inclined bedrock or as thicker hummocky deposits and are usually failed. Gleyed Eutric and Gleyed Eluviated Eutric Brunisols are the dominant soils, Gleyed Brunisolic Gray Luvisols are subdominant. These imperfectly drained soils display the mottling associated with episodic, near-surface seepage, plus the luvisolic tendencies common to most Panorama Ridge soils. Vegetation cover is dominated by the lodgepole pine/buffaloberry/grouseberry (C18) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s and does not readily reflect the seepage conditions. The PR3 Ecosite is much less extensive than the PR1 or PR2 Ecosites.

Geomorphology

The PR3 Ecosite is typified by morainal landforms consisting of the low lime phase of calcareous, medium textured till (Till C). Specifically, the PR3 till is predominantly weakly to moderately calcareous and contains material derived from noncalcareous Precambrian or Mesozoic strata mixed with material derived from calcareous strata. In most cases, Miette Group or noncalcareous Mesozoic strata underlie the till of PR3 tracts whereas other Panorama Ridge Ecosites occur on till overlying mainly calcareous strata. Surficial veneers of altered, medium textured eolian material (Eolian material B) occur sporadically and are quite thin. In some localities, the eolian material has been reworked by slowly moving seepage water.

Topographically, PR3 displays linear to irregular (hummocky) slopes on middle to lower valley walls. Underlying bedrock may or may not control the surface form since slope failure also often produces a hummocky surface. The PR3 Ecosite commonly occurs on failed till slopes, most of which are seepage-induced rotational slumps. Extinct rock glaciers and apron-like landforms consisting of till that has undergone flow (e.g. on lower valley walls near Hector Lake and Waterfowl Lakes in Banff) are also included in the PR3 concept. Slope failure status may be active or inactive. Future, recurrent failure including massive landslides, are a possi-

Table 303 Pedon (Alberta 1976 No. 96) description of a Gleyed Brunisolic Gray Luvisol of the PR3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: GLEYED BRUNISOLIC GRAY LUVISOL. SOIL MAP UNIT: OTHER, NOTATION: PR3.

LOCATION: MILITARY GRID REF. 11 UNB 5990 9920; NTS MAP AREA 82N 8E.

CLIMATE: 1910 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS MODERATE RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 2 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VTH=C10*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, FLUVIAL AND EOLIAN; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), MORAINAL (TILL); LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 23% SIMPLE SLOPE OF CLASS 6 (16-30%), FACING SOUTHWEST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,1000 M LONG; SOIL MOISTURE AND DRAINAGE: IMPERFECTLY DRAINED, SLOWLY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE PRESENT; 1.1 M TO WATERTABLE; NONSTONY; NONROCKY; PRESENT LAND USE: OUTDOOR RECREATION.

SPECIAL NOTES: SSN=BW6119*APN=783-880*RLU=1S*PCF*30R,1CB,1ST(5-9)*THIN,DISCONTINUOUS BM HORIZON AT TOP OF BM* SEEPAGE IS EPISODIC*LFM=MB/RI*

LF: 11 TO 10 CM, RANGE 0 TO 2 CM; HORIZON MOIST; ABUNDANT, FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

H: 10 TO 0 CM, RANGE 5 TO 14 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/1; ABUNDANT, FINE AND MEDIUM ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 1 CM, RANGE 0 TO 5 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/3; SILT LOAM; VERY WEAK, COARSE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; COMMON, VERY FINE PORES; BROKEN, ABRUPT HORIZON BOUNDARY.

BM: 1 TO 14 CM, RANGE 6 TO 18 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6, MATRIX MOIST 7.5YR 3/2; SILT LOAM; STRUCTURELESS, VERY COARSE, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; MANY, VERY FINE PORES; SMOOTH, ABRUPT HORIZON BOUNDARY.

2AB: 14 TO 30 CM, RANGE 12 TO 18 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/3; LOAM; FEW, FINE, DISTINCT, 7.5YR 5/6 MOTTLES; MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; MANY, VERY FINE PORES; FEW, VERY THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2BT: 30 TO 62 CM, RANGE 28 TO 36 CM; HORIZON MOIST; EXPED MOIST 10YR 5/3; LOAM; FEW, FINE, DISTINCT, 7.5YR 5/6 MOTTLES; MODERATE, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; COMMON, VERY FINE PORES; COMMON, CLAY FILMS IN MANY VOIDS/CHANNELS AND ON SOME VERTICAL AND HORIZONTAL PED FACES; WEAKLY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2BCKG: 62 TO 85 CM, RANGE 19 TO 27 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/3; LOAM; COMMON, FINE, PROMINENT, 10R 5/7 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; VERY WEAK, COARSE, SUBANGULAR BLOCKY SECONDARY STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; VERY FEW, VERY FINE PORES; FEW, THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; WEAK EFFERVESCENCE; MODERATELY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2CKG1: 85 TO 120 CM, RANGE 30 TO 40 CM; HORIZON WET; MATRIX MOIST 10YR 5/4; LOAM; COMMON, FINE, PROMINENT, 5YR 5/4 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; VERY FEW ROOTS; FEW, VERY FINE PORES; FEW, VERY FINE COARSE FRAGMENTS; MANY, VERY FINE VOIDS AND/OR CHANNELS ONLY; MODERATE EFFERVESCENCE; MODERATELY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS; MANY, DIFFUSE HORIZON BOUNDARY.

2CKG2: 120 TO 130 CM; HORIZON WET; MATRIX MOIST 10YR 5/4; LOAM; COMMON, FINE, PROMINENT, 5YR 4/6 MOTTLES; FRIABLE CONSISTENCE; FEW, VERY FINE PORES; MODERATE EFFERVESCENCE; MODERATELY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	6.1	42.80							
H	6.6	28.80	0.6						
AE	6.7	2.50	0.5	18.9		19.0	3.3	0.1	0.1
BM	6.9	4.10	0.5	36.5		29.7	5.9	0.1	0.2
2AB	6.9	0.60	0.5	8.8		7.7	2.1	<.1	0.1
2BT	7.1	0.20	4.0						
2BCKG	7.4		18.6						
2CKG1	7.5		12.7						
2CKG2	7.5		11.4						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
H				
AE	0.1		<.1	
BM	0.1		0.2	
2AB	0.1		<.1	
2BT	0.1		<.1	
2BCKG	<.1		<.1	
2CKG1				
2CKG2				

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
H								
AE								
BM								
2AB								
2BT								
2BCKG								
2CKG1								
2CKG2	9.0	16.0		6.0	2.2			

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
H										27		68	5	2
AE										21		78	1	1
BM										42		37	21	6
2AB										44		36	20	5
2BT										42		39	19	6
2BCKG										40		41	19	5
2CKG1										43		35	20	4
2CKG2														

bility on some PR3 tracts, notably a tract mapped as PR3/7c at Village Lake Louise in Banff investigated by TES Research and Consulting Ltd. (1973). Slopes commonly range from 5 to 45%. Weakly dissected slopes with shallow, subparallel gullies occur occasionally. Morainal veneers and bedrock outcrops rarely occur.

Soils

The dominant Gleyed Eutric Brunisols and Gleyed Eluviated Eutric Brunisols and the subdominant Gleyed Brunisolic Gray Luvisols of PR3 display varying degrees of luvisolic development and evidence of gleying. Weak textural B horizons, some with sufficient pedogenic clay films to be Bt horizons, occur at or near the till-eolian material interface. These may be overlain by iron, aluminum, and humus enriched Bm horizons developed in the Eolian material B veneers. These imperfectly drained soils usually display, in lower sola, mottles reflecting anaerobic - aerobic fluctuations associated with episodic, near-surface seepage. Orthic and Eluviated Eutric Brunisols are accessory soils occurring in well to moderately well drained localities where the fluctuating water table rarely reaches the control section. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly expressed where Eolian material B veneers are absent. In some localities, Ae horizons have been destroyed by recent surface modification such as avalanching, gullying, windthrow of trees, or shallow surface colluviation. Seeps with Gleysolic and Organic soils may cover up to 25% of PR3 tracts and are more common on PR3 than on Bryant (BY) or the other Panorama Ridge Ecosites. The low lime parent material promotes development of soils with deep sola compared to Bryant (BY) and other Panorama Ridge soils. In addition, Dystric Brunisols occur occasionally in strongly weathered localities.

A pedon illustrating Gleyed Brunisolic Gray Luvisols of the PR3 Ecosite is described in Table 303 and shown in Color Plate 59. The sample site is shown in Plate 150. The IIBt horizon of this pedon does not have a pronounced clay increase but it is the only horizon with clay films on some ped faces. Incomplete removal of calcium carbonate throughout the upper solum plus the presence of clay films in voids and channels throughout the lower solum are attributed to seepage water movement through the profile.

Vegetation

The closely related lodgepole pine/buffaloberry/grouseberry (C18) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s dominate the PR3 Ecosite. Factors affecting relative distributions of these two v.t.s are not understood. Also, they do not readily reflect the seepage condition. Commonly occurring accessory v.t.s include lodgepole pine/green alder/feathermoss (C10), lodgepole pine/feathermoss (C11), Engelmann spruce-subalpine fir/feathermoss (C13), and Engelmann spruce-subalpine fir/false azalea (C14). The latter two usually dominate small, unburned remnant, Engelmann spruce - subalpine fir stands commonly found on PR3 tracts. Minor amounts of lodgepole pine/false azalea/grouseberry (C20) and lodgepole pine/Labrador tea (C29) occur. Wet Lower Subalpine v.t.s such as spruce/Labrador tea/brown moss (O11) and willow-green alder/bluebell (S6) are associated with the seeps. The S6 v.t. is extensive on a northeast facing PR3 tract below The Whistlers in Jasper. Modification by avalanching and recent fires has occurred in some areas. A stand illustrating the C18 v.t. of the PR3 Ecosite is described in Table 304. This stand is located in the immediate vicinity (within 50 m) of the pedon sample site described above (Table 303).

Table 304 Stand (KS5015) illustrating the lodgepole pine/buffaloberry/grouseberry (C18) v.t. of the PR3 Ecosite.

TREE LAYER	
Abies lasiocarpa	03
Picea engelmannii	20
Pinus contorta	40
TALL SHRUB LAYER	
Picea engelmannii	12
Pinus contorta	.5
SHRUB LAYER	
Juniperus communis	01
Menziesia glabella	.5
Picea engelmannii	01
Ribes oxyacanthoides	.5
Shepherdia canadensis	65
HERB-DWARF SHRUB LAYER	
Arnica cordifolia	12
Carex concinna	.5
Chimaphila umbellata	.5
Cornus canadensis	01
Elymus innovatus	02
Epilobium angustifolium	.5
Erigeron peregrinus	.5
Fragaria virginiana	02
Linnaea borealis	.5
Pedicularis bracteosa	02
Stenanthium occidentale	05
Thalictrum occidentale	.5
Vaccinium scoparium	30
Viola orbiculata	04
BRYOID LAYER	
Brachythecium salebrosum	.5
Drepanocladus uncinatus	20
Eurhynchium pulchellum	.5
Pleurozium schreberi	03
Polytrichum spp.	01
Barbilophozia lycopodioides	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

In physiographic position, landform, and vegetation cover, PR3 resembles PR1 and PR2 but is separated by its gleyed soils that reflect imperfect drainage and seepage (Table 298). The Consolation Valley 1 (CV1) Ecosite, also occurring on failed till slopes, is wetter and is distinguished by the abundance of Gleysolic and Organic soils and wet Lower Subalpine v.t.s. Seepage conditions may limit some recreational uses of PR3. Slope failure is common and could be a continuing problem. Seeps and mudflows were created on a few sites by development on a ski slope (e.g. Ski Lake Louise on Whitehorn in Banff). Thorough hydrologic and engineering studies should be done on PR3 and adjoining tracts where major development is propsed.

PR4 - PANORAMA RIDGE 4 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, PR4, occurs on linear, inclined slopes consisting of calcareous, medium textured till (Till C) or calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). These slopes are erosional and were formed by the down- and sidecutting action of creeks and rivers following glacial deposition. Consequently, a landscape with an intricate slope aspect pattern and a concomitant soil and vegetation pattern characterizes PR4. Mesic northerly aspects are dominated by Orthic and Eluviated Brunisols and the Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/false azalea (C14) v.t.s. Eluviated Eutric Brunisols are more abundant than Orthic Eutric Brunisols. In contrast, subxeric to mesic southerly aspects exhibit their own soil pattern in which Orthic and Eluviated Eutric Brunisols are more abundant than Brunisolic Gray Luvisols and Orthic Regosols. These soils are associated with the lodgepole pine/juniper/bearberry (C3), lodgepole pine/buffaloberry/showy aster (C6), and lodgepole pine/buffaloberry/twinflower (C19) v.t.s.

Also, PR4 occurs on valley floors and is associated with rivers and creeks. Tracts mapped as PR4 are is generally long, narrow, and sinuous. Ravine- or canyon-like PR4 tracts include opposing stream banks plus the narrow floodplains that separate them (Fig. 49). On broad floors of major river valleys, the opposing river banks are usually mapped as two separate PR4 tracts when they are separated by wide, mappable glaciofluvial terraces or fluvial floodplains (Fig. 31). Tracts mapped as PR4 which are composed of one straight to gently curving river bank have narrow aspect ranges throughout their length, but on tracts with sinuous opposing river banks, all aspects may occur.

Geomorphology

The PR4 Ecosite is typified by inclined slopes consisting of calcareous, medium textured till (Till C) or calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). A few PR4 tracts (e.g. upper Altrude Creek and Kicking Horse Pass in Banff) are dominated by calcareous, coarse textured glaciofluvial material (Glaciofluvial material B), particularly on middle and upper slopes. Narrow floodplains and small fluvial fans at gully mouths, if present, are dominated by calcareous, coarse, stratified fluvial material (Fluvial material B). Surficial veneers of altered, medium textured eolian material (Eolian material B) occur sporadically and are quite shallow. Eolian material B is more extensive on the more stable northerly aspects. Shallow deposits of calcareous, medium textured colluvium (Colluvium C), derived primarily from till, occur on unstable portions of the landscape particularly on southerly aspects.

Topographically, the PR4 Ecosite displays short, linear slopes produced by the down- and sidecutting action of present or historical rivers and creeks through the glacial and proglacial deposits of valley floor benchlands and valley walls. Slopes commonly range from 45 to 70% and are usually dissected by subparallel gullies oriented perpendicular to the contour. Small fluvial fans and aprons emanating from gully mouth are common along slope bases. The PR4 Ecosite occurs as two opposing stream erosional scarps separated by narrow, level fluvial plains or as a single erosional scarp bounded upslope by glacial landforms, below by broad glaciofluvial terraces or fluvial floodplains. Some of the steeper slopes, particularly on southerly aspects, are being actively eroded with the material being distributed downslope as shallow colluvial or fluvial veneers. This surface erosion plus undercutting by streams has, in some localities, created bedrock escarpments. Bedrock outcrops are abundant on PR4+R tracts. These are often gorge-like. Blankets and veneers of glacial material occur occasionally, the veneers dominate on PR4X tracts. Occasionally, PR4 includes erosion remnant landforms consisting of opposing erosional slopes joined at the top by narrow glacial deposition surfaces. (e.g. lower Bath Creek, lower Norman Creek in Banff). In some cases, this erosional remnant topography may be ridged or hummocky. Failed slopes also occur occasionally (e.g. northerly aspect adjacent to Alexandra and North Saskatchewan Rivers in Banff).

Soils

Soils of the PR4 Ecosite are distributed in a pattern related to aspect. Northerly aspects

are dominated by Orthic and Eluviated Eutric Brunisols that resemble in their development the Bryant (BY) soils. These well to moderately well drained soils have B horizons that range from the rudimentary textural horizons associated with weathering of calcareous glacial material to the comparitively distinct Bm and Bf horizons associated with local occurrences of Eolian material B. The Eluviated Eutric Brunisols are more abundant but Orthic Eutric Brunisols dominate northerly aspects of some PR4 tracts in eastern Banff and Jasper where the incidence of eolian overlays is quite low. Orthic Humo-Ferric Podzols with podzolic Bf horizons above the parent material disconformity occur occasionally. Unstable localities with colluviating surfaces have Regosolic soils. Wet soils in seeps occur occasionally.

The well to rapidly drained soils of southerly aspects exist in a pattern related to degree of luvisolic development and stability. The dominant soils are Orthic and Eluviated Eutric Brunisols. Brunisolic Gray Luvisols and Orthic Regosols are subdominant. Where the landform is geomorphically stable, the soils have weak textural B horizons, some with sufficient pedogenic clay films to be Bt horizons, occurring at or near the glacial-eolian material interface. Iron, aluminum, and humus enriched Bm horizons developed in the Eolian material B veneers may overlie the textural B horizons, particularly in the Luvisolic soils. Eluvial (Ae) horizons are discontinuous across the landscape, having been eroded away or only weakly developed in the absence of Eolian material B. Orthic Gray Luvisols occur occasionally where the eolian veneer is absent. These soils of stable southerly aspects are similar to PR2 soils and exhibit stronger luvisolic tendencies than northerly aspect PR4 soils. Orthic Eutric Brunisols with weakly weathered Bmk horizons occur on recently or poorly stabilized sites. A pedon illustrating Eluviated Eutric Brunisols of southerly aspects of the PR4 Ecosite is described in Table 305 and shown in Color Plate 60.

Unstable, actively eroding localities on southerly aspects commonly have Orthic Regosols. Active colluviation, gullying, or sheet erosion inhibits normal pedogenic horizonation by maintaining fresh weathering surfaces. Thin (<5 cm), weakly weathered, Bmk horizons may occur. These Regosolic soils plus the genetically related, weakly developed Brunisolic soils resemble the soils of the Goat 1 (GT1) Ecosite.

Narrow fluvial floodplains included in several PR4 tracts have a variety of soils ranging from well to moderately well drained Regosolic to poorly drained Gleysolic soils. Development other than gleying and/or organic matter accumulation is not common. Soils of these localities resemble soils of the Pipestone (PP) and Hector (HC) Ecosections but are too small and narrow to be delineated at a mapping scale of 1:50,000.

Vegetation

Distribution of vegetation types on PR4 demonstrates the influence of aspect and both reflects and influences surface stability. A variety of Engelmann spruce - subalpine fir forest v.t.s, best represented by Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/false azalea (C14), occurs on northerly aspects. Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21), Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30), and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) also occur occasionally. Seral stage lodgepole pine v.t.s, best represented by lodgepole pine/false azalea/grouseberry (C20) and lodgepole pine/Labrador tea (C29) are common on some localities. Lodgepole pine/feathermoss (C11) and lodgepole pine/buffaloberry/twinflower (C19) also occur occasionally. Thus, northerly aspects of the PR4 Ecosite often resemble, vegetationally, the Bryant (BY) Ecosites, less often the PR1 Ecosite.

Vegetationally, southerly aspects resemble the PR2 Ecosite, occasionally the Goat 1 (GT1) Ecosite. The lodgepole pine/juniper/bearberry (C3), lodgepole pine/buffaloberry/showy aster (C6), and lodgepole pine/buffaloberry/twinflower (C19) v.t.s are most abundant. The C3 v.t., including an open variant, is more common on drier, less stable sites. Lodgepole pine/buffaloberry/grouseberry (C18) is common on some localities. Actively colluviating sites may have Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) or shrubby cinquefoil/bearberry-northern bedstraw (L1) vegetation. A stand representing vegetation of the pedon sample site described above (Table 305) and illustrating the C3 v.t. of southerly aspects of the PR4 Ecosite is presented in Table 306 and Plate 151.

Narrow fluvial floodplains included in several PR4 tracts usually have Engelmann spruce-subalpine fir open and closed forest, spruce open forest, or shrub vegetation. Vegetationally, these segments most closely resemble the Pipestone 3 (PP3), Pipestone 6 (PP6), Hector 1 (HC1), or Hector 4 (HC4) Ecosites. Vegetation modified by snow avalanching and recent fires occurs infrequently.

Discussion

The PR4 Ecosite is the least extensive of the Panorama Ridge Ecosites. In landform surface expression, soil development, and vegetation cover, northerly aspects most closely resemble the Bryant 1 and 2 (BY1, BY2) Eco-

Table 385 Pedon (Alberta 1978 No. 64) description of an Eluviated Eutric Brunisol from southerly aspect segments of the PR4 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: PR4.

LOCATION: MILITARY GRID REF. 11 UNB 7650 6000; NTS MAP AREA 82O 5W.

CLIMATE: 1530 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS POOR RELEVANCE TO THE SOIL SITE.

VEGETATION: VFm<JE8003> VTm<C3>..

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), MORAINAL (TILL), SEDIMENTARY; LANDFORM CLASSIFICATION: MORAINAL, GULLIED, INCLINED; SLOPE: 45% SLOPE OF CLASS 8 (46-70%), FACING SOUTHWEST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,200 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; SLIGHTLY STONY; NONROCKY.

SPECIAL NOTES: SS<WT8041<APH<4A3-13<R1U<15<PCP<BSR,1CB(8-5)3GR,2CB(6)<LFH<MI-V<

LF: 5 TO 0 CM, RANGE 4 TO 0 CM; HORIZON MOIST; MATRIX MOIST 5YR 3/2; PLENTIFUL, VERY FINE AND FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 5 CM, RANGE 3 TO 7 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/2; LOAM; VERY WEAK, FINE, PLATY STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE AND FINE AND MEDIUM ROOTS; 10% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

BTJ: 5 TO 12 CM, RANGE 6 TO 9 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 4/4; CLAY LOAM; WEAK, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY WEAK, FINE, GRANULAR SECONDARY STRUCTURE; FIRM CONSISTENCE; PLENTIFUL, VERY FINE AND FINE AND MEDIUM ROOTS; FEW, VERY FINE PORES; FEW, VERY THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; 10% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

BCK: 12 TO 23 CM, RANGE 9 TO 13 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/4; LOAM; VERY WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE AND MEDIUM ROOTS; MODERATE EFFERVESCENCE; VERY STRONGLY CALCAREOUS; 20% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

CK1: 23 TO 48 CM, RANGE 22 TO 28 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/3; LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE PSEUDO; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; 20% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

CK2: 48 TO 95 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/3.5; LOAM; WEAK, MEDIUM TO COARSE, SUBANGULAR BLOCKY STRUCTURE PSEUDO; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; FIRM CONSISTENCE; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; 30% GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	6.8	44.80		33.8		7.9	2.3	<.1	0.2
AE	5.9	2.70							
BTJ	7.0	1.44	3.0						
BCK	7.4		31.6						
CK1	7.5		38.5						
CK2	7.6		40.4						

PHYSICAL DATA

SURVEY (CON'T)

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST
LF					
AE		14.9	5.3		
BTJ					
BCK		15.9	8.8		
CK1					
CK2		14.6	7.6		

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF										45		40	15		
AE										35		29	36		
BTJ										44		37	19		
BCK										39		40	21		
CK1										38		42	20		2.10
CK2		99	81	69	67										

sites, occasionally the PR1 Ecosite. Southerly aspects most closely resemble the PR2 Ecosite, and in some localities the Goat 1 (GT1) Ecosite. However, PR4 is restricted to slopes with surface expression controlled by geomorphic erosion, mainly undercutting by streams, rather than by deposition. In some broad river valleys, PR4 tracts with only northerly or southerly aspects occur. The PR4 Ecosite resembles the Norquay 3 (NY3) and Goat 2 (GT2) Ecosites. However, NY3 occurs in the Montane Ecoregion rather than the Lower Subalpine. The GT2 Ecosite, like PR4, is a Lower Subalpine Ecosite but is restricted to eastern Banff and Jasper primarily in the Front Ranges. On PR4, Luvisolic soils and soils with luvisolic tendencies are more common than on NY3 or GT2 which also assists in separating the Ecosites. Regosolic soils combined with Douglas fir forest, shrub-herb meadow, and grassland vegetation of southerly aspects also assist in distinguishing NY3 and GT2 from the moister, more stable southerly aspects of PR4.

Table 306 Stand (JE8003) illustrating the lodgepole pine/juniper/bearberry (C3) v.t. of southerly aspect segments of the PR4 Ecosite.

TREE LAYER	
Picea glauca	02
Pinus contorta	15
Pseudotsuga menziesii	07
TALL SHRUB LAYER	
Pinus contorta	01
SHRUB LAYER	
Pinus contorta	.5
Pseudotsuga menziesii	.5
Shepherdia canadensis	02
HERB-DWARF SHRUB LAYER	
Achillea millefolium	.5
Amelanchier alnifolia	.5
Anemone patens	.5
Arctostaphylos uva-ursi	10
Aster ciliolatus	.5
Calamagrostis rubescens	10
Calypso bulbosa	.5
Carex concinna	.5
Carex concinnoides	03
Elymus innovatus	20
Fragaria virginiana	.5
Galium boreale	.5
Hedysarum sulphurescens	.5
Juniperus communis	20
Linnaea borealis	02
Picea glauca	.5
Pseudotsuga menziesii	.5
Pyrola secunda	.5
Rosa acicularis	.5
Senecio canus	.5
Spiraea lucida	.5
Stenanthium occidentale	.5
Zygadenus elegans	.5
BRYOID LAYER	
Bryum spp.	.5
Caloplaca sinapisperma	.5
Caloplaca jungermanniae	.5
Cetraria chlorophylla	.5
Cetraria ericetorum	.5
Cladonia coccifera	.5
Cladonia deformis	.5
Cladonia ecmocyna	01
Cladonia mitis	.5
Cladonia pyxidata	.5
Dicranum brevifolium	.5
Dicranum muehlenbeckii	.5
Dicranum polysetum	.5
Drepanocladus uncinatus	.5
Eurhynchium pulchellum	.5
Hylocomium splendens	02
Lecidea granulosa	.5
Peltigera aphthosa	01
Peltigera canina	.5
Peltigera rufescens	01
Pleurozium schreberi	05
Pohlia nutans	.5
Psoroma hypnorum	.5
Rhizocarpon disporum	.5
Rhizocarpon geographicum	.5
Rinodina turfacea	.5
Stereocaulon tomentosum	.5
Tortula ruralis	.5
Barbilophozia hatcheri	.5
EPIPHYTES	
Candullariella aurella	.5
Cetraria pinastri	.5
Lecanora coilocarpa	.5
Lecidea fuscescens	.5
Letharia vulpina	.5
Parmelia sulcata	.5
Parmeliopsis ambigua	.5
Physcia millegrana	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

PR6 - PANORAMA RIDGE 6 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, PR6, occurs on glacial landforms consisting of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). Inclined surfaces reflect the underlying bedrock. Hummocky surfaces may be either bedrock controlled or depositional. The PR6 Ecosite is generally confined to valley floors including benchlands on broad valley floors and to lower valley wall slopes. It is characterized by a soil pattern in which Eluviated Eutric Brunisols are dominant, Orthic Eutric Brunisols and Brunisolic Gray Luvisols are subdominant. Luvisolic tendencies are common in the Brunisolic soils. Vegetation cover is dominated by the lodgepole pine/feathermoss (C11), lodgepole pine/buffaloberry/grouseberry (C18), lodgepole pine/buffaloberry/twinflower (C19), and lodgepole pine/Labrador tea (C29) v.t.s and reflects complex fire histories within the Lower Subalpine.

Geomorphology

The PR6 Ecosite is typified by glacial landforms consisting of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). Surficial veneers of altered medium textured eolian material (Eolian material B) occur sporadically and are quite thin. Eolian material B is more extensive on PR6, especially in western Banff and southwestern Jasper, than on the other Panorama Ridge Ecosites. This is attributable to gentler slopes and less erosion on PR6. Calcareous, medium textured till (Till C) often underlies the ice contact stratified material.

Topographically, the PR6 Ecosite displays, on valley floors including benchlands, the irregularly shaped knolls and depressions of hummocky surfaces. Linear, inclined slopes usually occur on lower valley walls above the valley floors. Bedrock control is responsible for the inclined slopes and sometimes for the hummocky surface expression. Occasionally, ridged surfaces that reflect underlying bedrock occur. The hummocky surface expression of ice contact stratified deposits is often depositional in origin. Kettles, kames, and eskers are depositional features that occur on some PR6 tracts. In some PR6 tracts of lower valley wall slopes, hummocky depositional surfaces are superimposed upon inclined slopes that reflect the underlying bedrock surface. Failed slopes occur infrequently. Slopes commonly range from 5 to 45%. Tracts mapped as PR6 with steeper slopes occur occasionally (e.g. west side of Dolomite Creek above Isabella Lake in Banff) as do features such as gullies on steep linear slopes, and small glaciofluvial terraces. Veneers of glacial drift

and rock outcrops occur rarely except in PR6+R tracts where rock escarpments are common.

Soils

The dominant Eluviated Eutric Brunisols and subdominant Orthic Eutric Brunisols and Brunisolic Gray Luvisols display varying degrees of luvisolic and eluvial (Ae) horizon development under predominantly well drained conditions. Weak textural B horizons, some with sufficient pedogenic clay films to be Bt horizons, occur at or near the glacial-eolian material interface. Iron, aluminum, and humus enriched Bm horizons developed in the Eolian material B veneers may overlie the textural B horizons, particularly in the Luvisolic soils. Genetically related Orthic Gray Luvisols occur in minor amounts. Eluvial (Ae) horizons, although discontinuous across the landscape particularly in the absence of Eolian material B, occur more extensively than on the other Panorama Ridge Ecosites. Greater abundance of Eolian material B veneers and more gentle slopes favor Ae development on PR6. Surface modifications such as avalanching, gullying, windthrow of trees, and shallow surface colluviation that occur in some localities inhibit Ae development. Regosolic soils occur occasionally on active fluvial and colluvial sites. Lithic soil phases and wet soils on seeps occur rarely.

A pedon illustrating Eluviated Eutric Brunisols of the PR6 Ecosite is described in Table 307 and shown in Color Plate 61. It is developed in a veneer of Eolian material B overlying a relatively fine textured example of Ice Contact Stratified Drift B. Luvisolic tendencies are not evident in this pedon because of the weak weathering and high but variable clay content in the glacial deposit.

Vegetation

Vegetation of the PR6 Ecosite is dominated by the lodgepole pine/feathermoss (C11), lodgepole pine/buffaloberry/grouseberry (C18), lodgepole pine/buffaloberry/twinflower (C19), and lodgepole pine/Labrador tea (C29) v.t.s. Factors affecting relative distributions of these types are not completely understood. The C11 and C29 v.t.s, seral to Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) of the Bryant (BY4) Ecosite, probably occur on older or less frequently burned areas. The C29 v.t. tends to be more common in eastern portions of the parks, particularly in Jasper. Lodgepole pine/juniper/bearberry (C3), lodgepole pine/buffaloberry/showy aster (C6), and lodgepole pine/false azalea/grouseberry (C20) are commonly occurring accessory v.t.s. The C3 v.t. occurs on steep, poorly stabilized, subxeric to mesic sites whereas C6 occurs on mesic sites at the low elevation range of PR6, and C20 is associated with PR6 in the Main Ranges. Lodgepole pine/green alder/feathermoss (C10), Engelmann spruce-subalpine fir/feathermoss (C13), and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) occur in minor amounts. A stand representing vegetation of the pedon sample site described above (Table 307) and illustrating the C11 v.t. of the PR6 Ecosite is presented in Table 308 and Plate 152.

Discussion

Genetic material and/or landform surface expression differentiate PR6 from the other PR Ecosites. Additionally, PR3 is affected by seepage and PR4 displays a pattern of soils and vegetation controlled by aspect (Table 298). The Bryant 4 (BY4) Ecosite has the same landforms and genetic material but is dominated by Engelmann spruce - subalpine fir forest occurring on soils with only rudimentary luvisolic development whereas PR6 is characterized by C11, C18 and C19 v.t.s. The Baker Creek 4 (BK4) Ecosite has similar landforms, genetic material, and vegetation to PR6 on its upland (dry) segment but the dry-wet pattern (includes about 30% of wet depressional areas) separates it from PR6.

PT - PATRICIA ECOSECTION

The Patricia Ecosection is confined to gently sloping morainal landforms comprised of calcareous, medium textured till (Till C) in the Montane Ecoregion of Banff and Jasper. The dominant soils (Brunisolic and Luvisolic) and vegetation (lodgepole pine and aspen forests) reflect mesic, well drained moisture conditions, stable geomorphic materials, and a complex fire history.

Patricia Ecosites occur throughout the Montane Ecoregion on broad valley floor benchlands associated with the Athabasca, North Saskatchewan, and Bow River drainage systems. Four Patricia Ecosites are differentiated (Table 309) based on vegetational differences, predominance of lithic soil phases, or a dry versus wet pattern of soils and vegetation. Figs. 50 and 47 illustrate a schematic physiographic distribution of PT Ecosites in relation to one another and some other Ecosites.

PT1 - PATRICIA 1 ECOSITE

Ecosite Concept

The Montane Ecosite, PT1, occurs on ridged or hummocky moraine or morainal blankets overlying ridged or hummocky bedrock. The moraines consist of calcareous, medium textured till (Till C). The dominant soils are Orthic and Eluviated Eutric Brunisols and Brunisolic Gray Luvisols. Vegetation cover is dominated by lodgepole pine/buffaloberry/

Table 307 Pedon (Alberta 1978 No. 67) description of an Eluviated Eutric Brunisol of the PR6 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: PR6.

LOCATION: MILITARY GRID REF. 11 UPG 1050 4480; NTS MAP AREA 82J 14W.

CLIMATE: 1650 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 2 DEG(C) AT 50 CM IN JUNE.

VEGETATION: VPN=JE8888= VTN=C11=.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), EOLIAN, SEDIMENTARY; PARENT MATERIAL 2: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), GLACIOFLUVIAL AND MORAINAL (TILL), SEDIMENTARY; LANDFORM CLASSIFICATION: GLACIO FLUVIAL AND MORAINAL, HUMMOCKY; SLOPE: 28% COMPLEX SLOPE OF CLASS 6 (16-30%), FACING WEST. SITE AT UPPER SLOPE POSITION, 60 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; MONOCKY.

SPECIAL NOTES: SSH=NT8804=APH=011-010=PCF=1BR(2-5)4BR,2CB(4)3GR,1CB(5)1GR(6)5GR,1CB(7)=LF?=HFBH

LF: 14 TO 0 CM, RANGE 18 TO 17 CM; MATRIX MOIST 5YR 3/2; PLENTIFUL, FINE AND MEDIUM AND COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AE: 0 TO 3 CM, RANGE 0 TO 4 CM; MATRIX MOIST 10YR 5/2; SILT LOAM; VERY WEAK, MEDIUM, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; COMMON, VERY FINE PORES; BROKEN, CLEAR HORIZON BOUNDARY.

BM: 3 TO 16 CM, RANGE 12 TO 15 CM; MATRIX MOIST 7.5YR 5/6, MATRIX MOIST 5YR 4/6; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE AND MEDIUM ROOTS; COMMON, VERY FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

2BCK: 16 TO 29 CM, RANGE 10 TO 16 CM; MATRIX MOIST 7.5YR 6.5/4; GRAVELLY SILTY CLAY LOAM; MODERATE, FINE, SUBANGULAR BLOCKY STRUCTURE; MODERATE, VERY FINE, GRANULAR SECONDARY STRUCTURE; FRIABLE CONSISTENCE; FEW, FINE AND MEDIUM ROOTS; MODERATE EFFERVESCENCE; MODERATELY CALCAREOUS; 40% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2CK1: 29 TO 52 CM, RANGE 15 TO 30 CM; MATRIX MOIST 10YR 6/2; SILTY CLAY LOAM; MODERATE TO STRONG, MEDIUM, ANGULAR BLOCKY STRUCTURE PSEUDO; FIRM CONSISTENCE; VERY FEW, FINE AND MEDIUM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 20% GRAVELLY AND COBBLY COARSE FRAGMENTS; BROKEN, DIFFUSE HORIZON BOUNDARY.

2CK2: 52 TO 75 CM, RANGE 20 TO 35 CM; MATRIX MOIST 10YR 6/2; SILTY CLAY LOAM; STRONG, MEDIUM, ANGULAR BLOCKY STRUCTURE PSEUDO; FIRM CONSISTENCE; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; BROKEN, DIFFUSE HORIZON BOUNDARY.

2CK3: 75 TO 110 CM; MATRIX MOIST 10YR 6/2; VERY GRAVELLY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; STICKY CONSISTENCE; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 70% GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.4	49.00							
AE	4.5	3.10		23.0		3.8	1.0	0.1	0.1
BM	5.3	2.49		27.2		4.6	0.8	0.1	0.2
2BCK	7.1		13.8						
2CK1	7.3		49.4						
2CK2	7.5		40.3						
2CK3	7.5		58.5						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	0.1		0.2	
2BCK				
2CK1				
2CK2				
2CK3				

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS % PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF															
AE										14	72		14		
BM										18	75		7		
2BCK										16	55		29		
2CK1										7	61		32		
2CK2	99	99	99	99						5	68		27		1.79
2CK3	99	81	29	16						34	53		13		

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE		30.3	8.9										
BM													
2BCK		27.3	10.1										
2CK1													
2CK2		27.1	11.1			15.0	34.0		11.0	1.9		46	19
2CK3		16.6	6.6			14.0	28.0		11.0	1.9		11	17

Figure 50 Landscape schematic showing the relationship of the Patricia (PT) Ecosites to other Ecosites.

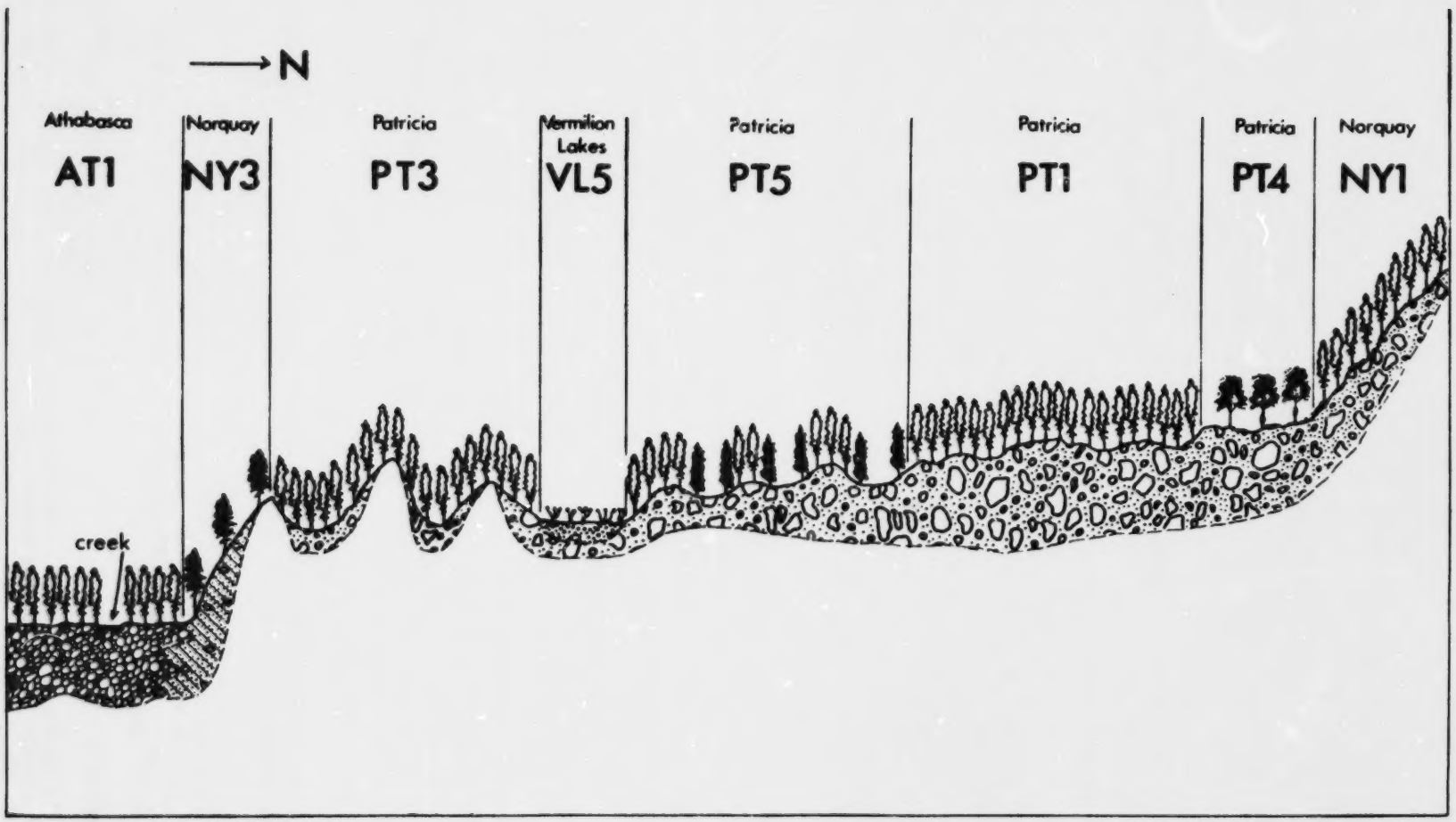


Table 308 Stand (JE8005) illustrating the lodgepole pine/feathermoss (C11) v.t. of the PR6 Ecosite.

TREE LAYER	
Abies lasiocarpa	06
Picea engelmannii	09
Pinus contorta	30
TALL SHRUB LAYER	
Abies lasiocarpa	01
Picea engelmannii	02
SHRUB LAYER	
Abies lasiocarpa	.5
Ledum groenlandicum	.5
Menziesia glabella	03
Picea engelmannii	.5
Rosa acicularis	.5
Shepherdia canadensis	.5
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	02
Arnica cordifolia	.5
Aster conspicuus	.5
Calypso bulbosa	.5
Carex concinnoides	.5
Cornus canadensis	01
Elymus innovatus	.5
Epilobium angustifolium	.5
Ledum groenlandicum	03
Linnaea borealis	.5
Picea engelmannii	.5
Pyrola asarifolia	.5
Pyrola secunda	.5
Rosa acicularis	.5
Vaccinium scoparium	03
Stenanthium occidentale	.5
Equisetum scirpoides	.5
Lycopodium annotinum	.5

BRYOID LAYER	
Cladonia cenotea	.5
Cladonia chlorophaea	.5
Cladonia coniocraea	.5
Cladonia deformis	.5
Cladonia ecmocyna	.5
Cladonia pyxidata	.5
Cladonia verticillata	.5
Dicranum fragilifolium	.5
Dicranum scoparium	.5
Hylocomium splendens	40
Icmadophila ericetorum	.5
Peltigera aphthosa	.5
Peltigera canina	.5
Pleurozium schreberi	30
Ptilium crista-castrensis	05
Stereocaulon tomentosum	.5
Barbilophozia lycopodioides	.5
Ptilidium ciliare	.5
EPIPHYTES	
Bryoria fremontii	.5
Bryoria glabra	.5
Cetraria chlorophylla	.5
Cetraria halei	.5
Cetraria merrillii	.5
Cetraria pinastri	.5
Hypogymnia enteromorpha	.5
Hypogymnia imshaugii	.5
Hypogymnia physodes	.5
Hypogymnia tubulosa	.5
Lecidea cinnabarina	.5
Letharia vulpina	.5
Parmelia sulcata	.5
Parmeliopsis ambigua	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Table 309 General features of the Patricia (PT) Ecosites.

Ecosite	Landform	Soils	Vegetation
PT1	Till C; ridged, hummocky, blanket	Brunisolic, Luvisolic	lodgepole pine forest
PT3	Till C; veneer > bedrock; ridged	Brunisolic > Luvisolic (lithic phases of both)	lodgepole pine forest
PT4	Till C; ridged, blanket	Brunisolic, Luvisolic	aspen forest
PT5	Till C; ridged > horizontal fen	Dry[40]: Brunisolic, Luvisolic Wet[40]: Gleysolic, Organic	Dry[40]: lodgepole pine forest Wet[40]: black spruce-lodgepole pine forest, spruce open forest

showy aster (C6) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s.

The PT1 Ecosite is the most extensive Patricia Ecosite and is commonly found on broad valley floor benchlands throughout the Montane Ecoregion. Occasionally, PT1 tracts occur on lower slopes of valley walls.

Geomorphology

The PT1 Ecosite is typified by hummocky or ridged moraines or by morainal blankets overlying hummocky or ridged bedrock. These moraines are characterized by calcareous, medium textured till and include relatively extensive areas of the low lime, sandy loam textured phase of Till C in the Athabasca and Miette River valleys above Jasper townsite. A few PT1 tracts north of Ashlar Ridge in the Fiddle River valley in Jasper also consist of low lime till. Calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) is usually a significant constituent of PT1 tracts that adjoin Athabasca 1 (AT1), Norquay 3 (NY3),

Panorama Ridge 6 (PR6), or Rocky 1 (RK1) tracts. In Jasper, good examples of PT1 tracts containing Ice Contact Stratified Drift B occur in the Leach Lake - Hardisty Creek area and along the erosional escarpment of the Snake Indian River. Veneers of calcareous, medium textured eolian material (Eolian material A) or altered, medium textured eolian material (Eolian material B) occur sporadically. Where present, these very thin eolian materials add carbonates to the soil surface or promote development of upper sola Bm horizons respectively.

Topographically, PT1 displays a series of subparallel ridges or a complex sequence of rounded depressions and irregular to conical shaped knolls. Relief is low compared to the PT3 Ecosite, breaks in slope are relatively subtle, and ridge or knoll crests and depressional areas are broad with gentle slopes. On benchlands, slopes normally range from 2 to 45%. Localities with slopes <5% have an undulating surface expression. Occasionally, inclined moraine or morainal blankets with linear slopes (usually of 30-45%) occur on lower valley walls. Rarely does bedrock outcrop on PT1 although morainal veneers exist, usually adjacent to PT3 tracts.

Soils

The various soils of the PT1 Ecosite are genetically similar and display varying degrees of eluvial (Ae) horizon and luvisolic development. Orthic and Eluviated Eutric Brunisols and Brunisolic Gray Luvisols dominate PT1 and are characterized by thin sola developed under well drained conditions. These soils have weak textural B horizons, some with sufficient pedogenic clay film development to be Bt horizons, occurring at or below the till-eolian interface. Iron, aluminum, and humus enriched Bm horizons developed in the Eolian material B veneers often overlie the textural B horizons. These upper sola Bm horizons are absent on the accessory Orthic Gray Luvisols. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly expressed in the absence of Eolian material B. In some localities, surface erosion or deposition inhibits Ae development.

A pedon illustrating the Eluviated Eutric Brunisols of PT1 is described in Table 310 and shown in Color Plate 62. This profile differs from modal soils by having, in its upper solum, lime that is probably derived from wind blown particles. Although textural Btj and Bt horizons frequently contain low amounts of lime, the 11.4% calcium carbonate equivalent in this pedon's Btj horizon is higher than normal.

Three groups of soil occur in minor amounts on PT1. Small wet depressions with Rego and Orthic Gleysols and Terric Mesisols may occupy up to 20% of some tracts. Orthic and Eluviated Dystric Brunisols occur rarely and only on the low lime till of western Jasper. Cumulic Regosols occur occasionally and are associated with fresh deposits of calcareous, medium textured eolian material (Eolian material A) on PT1 tracts adjacent to TA3 tracts in the lower Athabasca River valley in Jasper. These recent additions of highly calcareous material to the soil surface have retarded normal soil development. Lithic soil phases occur infrequently and are associated with morainal veneers.

Vegetation

The PT1 Ecosite is dominated by the closely related lodgepole pine/buffaloberry/showy aster (C6) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s that reflect the extensive effects of fire in the Montane Ecoregion. The vegetation of a site near the pedon sample site is described in Table 311. This plot differs slightly from the C19 v.t. central concept in that the *Shepherdia canadensis* cover is less than 10% but a low cover of buffaloberry is common to the C19 v.t.s occurring on PT1. Accessory v.t.s on the PT1 Ecosite are lodgepole pine/juniper/bearberry (C3) and lodgepole pine/green alder/feathermoss (C10). The C3 v.t. is common on the elevated, driest portions of the landscape such as ridge and hummock crests. In Jasper C10 occurs near the Lower Subalpine - Montane boundary on cooler, more moist northerly-facing slopes. Subsurface seepage is sometimes associated with the C10 v.t.

Several v.t.s occur in minor amounts on PT1 tracts. Small pockets of aspen/hairy wild rye-peavine (C16) are common throughout both parks. Douglas fir/hairy wild rye (C1) occurs occasionally on steep dry sites, particularly where there are shallow soils. White spruce/Douglas fir/feathermoss (C5) occurs on some north - facing slopes that have not been recently burned. Lodgepole pine/feathermoss (C11) and lodgepole pine/buffaloberry/grouseberry (C18) are closely related to the dominant v.t.s and occasionally occur near the Lower Subalpine - Montane boundary. Various Montane wet v.t.s such as black spruce-lodgepole pine/willow/sedge (C8) and water sedge-beaked sedge (H11) are found on the Gleysolic and Organic soils of wet depressional sites.

Discussion

The PT1 Ecosite resembles the PR2 Ecosite in soil development and vegetation cover. However, PR2 belongs to the Lower Subalpine portion of the Subalpine Ecoregion and includes steeper, frequently linear slopes on valley walls whereas PT1 occurs primarily on valley floor benchlands in the Montane Eco-

Table 310 Pedon (Alberta 1978 No. 86) description of an Eluviated Eutric Brunisol of the PT1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: PT1.

LOCATION: MILITARY GRID REF. 11 UPG 1000 6800; NTS MAP AREA 82O 3H.

CLIMATE: 1430 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS GOOD RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 5 DEG(C) AT 50 CM IN MAY.

VEGETATION: VMN=JC8083+VTN=C19+..

SOIL SITE: PARENT MATERIAL 1: SKELETAL (>35% OF PARTICLES 2-25 CM) AND FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL); LANDFORM CLASSIFICATION: MORAINAL, HUMMOCKY; SLOPE: 6% COMPLEX SLOPE OF CLASS 4 (6-9%), FACING SOUTH; SITE AT MIDDLE POSITION, 50 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, SLOWLY PERVIOUS, SLOW SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; HUMMOCKY.

SPECIAL NOTES: SSM=BM8083+APM=018-224+RLU=1B+SSC=CB+PCF=46R,1CB(2-3)4GR,2CB,1ST(4-5)+SOME PLACES HAVE THIN EOLIAN VENEER+

LF: 2 TO 0 CM, RANGE 1 TO 3 CM; MATRIX MOIST 10YR 2/1; ABUNDANT, VERY FINE AND FINE AND MEDIUM ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 4 CM, RANGE 3 TO 6 CM; MATRIX MOIST 10YR 4/3; GRAVELLY LOAM; WEAK, COARSE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE AND MEDIUM ROOTS; HIGHLY POROUS, MANY, VERY FINE AND FINE PORES; 30% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BTJ: 4 TO 16 CM, RANGE 10 TO 15 CM; MATRIX MOIST 7.5YR 5/4; GRAVELLY LOAM; VERY WEAK, COARSE, SUBANGULAR BLOCKY STRUCTURE; WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE; FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE AND MEDIUM ROOTS; HIGHLY POROUS, COMMON, VERY FINE AND FINE PORES; 30% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BCK: 16 TO 39 CM, RANGE 28 TO 26 CM; MATRIX MOIST 10YR 4/2; GRAVELLY LOAM; WEAK, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; VERY FEW, VERY FINE PORES; STRONG EFFERVESCENCE; 40% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK: 39 TO 70 CM; MATRIX MOIST 10YR 5/3; GRAVELLY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FIRM CONSISTENCE; STRONG EFFERVESCENCE; 40% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LF	6.6	36.60	5.8
AE	6.8	2.00	1.4
BTJ	7.4	1.90	11.4
BCK	7.6		49.5
CK	7.8		61.0

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS														
	% PASSING										% OF SAMPLE				
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF															
AE										47		43	10		
BTJ										45		36	17		
BCK										47		40	13		
CK		99	81	63	58					38		41	21		2.00

PHYSICAL DATA

	MOISTURE STATUS (%)					ENGINEERING							
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE		21.9	11.3										
BTJ													
BCK													
CK		14.1	6.8			12.0	16.0					48	18

region. Also, PR2 vegetation cover is more heterogeneous and has, as the dominant v.t., lodgepole pine/buffaloberry/grouseberry (C18). The PT3 Ecosite is also similar to PT1 but is dominated by lithic phase rather than deep soils and has significant proportions of the lodgepole pine/juniper/bearberry (C3) rather than C19 v.t. Landform and soils of PT4 are similar to PT1 but vegetation cover is dominated by aspen/hairy wild rye-peavine (C16) rather than C19. The PT5 Ecosite is characterized by a complex landscape pattern comprised of about 60% dry segments (upland), too small to delineate but otherwise identical in most cases to PT1, and 40% wet segments.

Table 311 Stand (AW6037) illustrating the lodgepole buffaloberry/twinflower (C19) v.t. of the PT1 Ecosite.

TREE LAYER	
Pinus contorta	65
SHRUB LAYER	
Amelanchier alnifolia	.5
Juniperus communis	01
Picea glauca	01
Rosa acicularis	03
Shepherdia canadensis	04
Spiraea lucida	01
HERB-DWARF SHRUB LAYER	
Achillea millefolium	.5
Allium cernuum	.5
Arctostaphylos uva-ursi	03
Aster ciliolatus	.5
Aster conspicuus	03
Calamagrostis rubescens	45
Carex spp.	.5
Elymus innovatus	05
Fragaria virginiana	01
Galium boreale	.5
Hedysarum sulphurescens	03
Lathyrus ochroleucus	02
Linnaea borealis	38
Pyrola secunda	.5
Pyrola virens	.5
Viola adunca	.5
Zygadenus elegans	.5
BRYOID LAYER	
Brachythecium spp.	.5
Dicranum spp.	.5
Drepanocladus uncinatus	02
Hylocomium splendens	02
Peltigera aphthosa	01
Pleurozium schreberi	01

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

PT3 - PATRICIA 3 ECOSITE

Ecosite Concept

The Montane Ecosite, PT3, is dominated by a landform pattern comprised of discontinuous morainal veneers overlying ridged bedrock plus exposed bedrock ridges on topographic highs. The morainal segments, consisting of calcareous, medium textured till (Till C), are more extensive than the exposed bedrock segments. Lithic phases of the dominant Orthic and Eluviated Eutric Brunisols and subdominant Brunisolic Gray Luvisols characterize the soils of PT3. Vegetation cover is dominated by lodgepole pine/juniper/bearberry (C3), lodgepole pine/buffaloberry/showy aster (C6) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s.

The PT3 Ecosite is most extensive on the broad valley floor benchlands of the Athabasca River between Mount Kerkeslin and Jasper townsite and of the Miette River between the west gate and Jasper townsite. It occurs less extensively in the lower Athabasca, Snake Indian, and Fiddle River valleys in Jasper. In Banff, a few PT3 tracts occur near Lake Minnewanka and Sundance Canyon.

Geomorphology

The PT3 Ecosite is characterized by a complex landform pattern comprised of discontinuous morainal veneers overlying ridged bedrock that crops out on topographic highs. The morainal segments, consisting of calcareous, medium textured till (Till C), are more extensive than the exposed bedrock segments. Deeper morainal deposits resulting in morainal blanket landforms are an accessory feature, which mantles many of the topographic lows between ridges. Calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) occurs occasionally, as an accessory genetic material, replacing till in many of the severely eroded localities or localities adjacent to glaciofluvial terraces. Examples of PT3 tracts with veneers of Ice Contact Stratified Drift B occur in the Mount Hardisty area of Jasper. Veneers of calcareous, medium textured eolian material (Eolian material A) and altered, medium textured eolian material (Eolian material B) occur sporadically and are most extensive on depressional areas. Where present, these very thin eolian materials add carbonates to the soil surface or promote development of upper sola Bm horizons respectively.

Underlying and exposed bedrock is either Miette Group, as in the middle Athabasca and lower Miette river valleys, or calcareous Paleozoic strata. Low lime phases of Till C and Ice Contact Stratified Drift B tend to dominate on the areas underlain by Miette Group strata but associated soils are dominantly Eutric Brunisols and Luvisolics. Occasionally Dystric Brunisols occur, particularly on weathered parts of exposed Miette Group bedrock.

Topographically, PT3 displays a series of subparallel ridges usually <1 km apart with slopes <150 m long (about 200 m long on the steepest terrain). Bedrock escarpments form sharp, narrow ridge crests. Residual material (weathered bedrock) occurs locally on this exposed bedrock. Shallow till deposits that thicken downslope mantle the ridge slopes. Local occurrences of shallow colluvium can be found on and below the steepest, generally south-facing scarps. Occasionally, narrow bands of shallow fluvial materials overlie the till in depressions containing intermittent streams. Slopes commonly range from 9 to 70%. Depressional localities may have slopes <9%. Exceptionally steep localities (e.g. some south-facing scarps) have slopes ranging to 100%.

Soils

Various soils of the PT3 Ecosite are genetic-

ally similar and display varying degrees of eluvial (Ae) horizon and luvisolic development and are influenced by shallow parent materials. These soils are distributed in a pattern reflecting depth to bedrock. Lithic phase Orthic and Eluviated Eutric Brunisols that display weak luvisolic tendencies are dominant. The subdominant Brunisolic Gray Luvisols have weakly developed Bt horizons and are most abundant on the deeper glacial deposits in depressions between ridges. Lithic phase Brunisolic Gray Luvisols also occur often. The weak textural B horizons of PT3 soils are developed at or near the till-eolian interface and are often overlain by iron, aluminum, and humus enriched Bm horizons developed in the veneers of altered, medium textured eolian material (Eolian material B). Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly expressed in the absence of Eolian material B. In some localities, surface disturbances by erosional and depositional processes inhibit Ae development.

Soils of the PT3 Ecosite are rapidly to well drained. Rapidly drained localities are subdominant and confined to ridge crests and upper slopes with southerly aspects. Vegetation associated with the dry sites includes the lodgepole pine/juniper/bearberry (C3) and Douglas fir/hairy wild rye (C1) v.t.s.

A pedon illustrating lithic phase Eluviated Eutric Brunisols of PT3 is described in Table 312 and shown in Color Plate 63. The lithic contact is estimated to be at about 1 m in this profile. Bedrock crops out at the slope crest <10 m above the sample site. This pedon is developed in the low lime, sandy loam textured phase of Till C. Consequently, the Btj horizon contains very little calcium carbonate and is developed deeper in the profile than is normal for PT3.

Wet terrain may occupy up to 20% of some PT3 tracts and is usually associated with the shallow fluvial deposits of narrow depressions. Soils on these localities are Orthic and Rego Gleysols and Terric Mesisols. Other soils occurring in minor amounts are Orthic and Eluviated Dystric Brunisols on low lime till and locally on weathered Miette Group bedrock, Orthic Regosols associated with shallow colluvial deposits on steep slopes, Cumulic Regosols associated with the infrequent occurrences of Eolian material A, and Orthic Gray Luvisols.

Vegetation

The PT3 Ecosite is dominated by the closely related lodgepole pine/juniper/bearberry (C3), lodgepole pine/buffaloberry/showy aster (C6), and lodgepole pine/buffaloberry/twinflower (C19) v.t.s that reflect the extensive effects of fire in the Montane Ecoregion and the mesic to subxeric moisture conditions controlled by topography and shallow unconsolidated deposits. These three types form a pattern in which the mesic C6 and C19 v.t.s span depressional and lower to middle slope portions of the strongly ridged landscape and the subxeric C3 v.t. occurs on upper slopes and crests where shallow soils and exposed bedrock are common. Also, C19 tends to be more common on northerly aspects and in depressional areas, whereas C3 and C6 are more common on southerly aspects. The vegetation of the pedon sample site is described in Table 313 and shown in Plate 153. This plot illustrates the C3 v.t. on PT3.

Douglas fir/hairy wild rye (C1) occurs as an accessory v.t. It replaces C3 on steeper, south-facing slopes and ridge crests that have very shallow, rapidly drained soils.

Several v.t.s occur in minor amounts on PT3 tracts. Occurring in small pockets of minor areal extent is aspen/hairy wild rye-peavine (C16) throughout both parks. Lodgepole pine/green alder/feathermoss (C10) or white spruce-Douglas fir/feathermoss (C5) occur occasionally on relatively steep, cool, moist, northerly aspects. Also occurring infrequently in small pockets are the subxeric v.t.s shrubby cinquefoil/bearberry-northern bedstraw (L1) on exceptionally steep, unstable, colluvial slopes, and spotted saxifrage-hairy wild rye (H20) on exposed rock outcrops. Small amounts of various wet Montane v.t.s, such as white spruce/prickly rose/horsetail (C4), spruce/Labrador tea/brown moss (O11), or water sedge-beaked sedge (H11) are found on narrow depressions in association with shallow fluvial deposits and/or wet soils.

Discussion

The PT3 Ecosite is characterized by a complex landscape pattern which is strongly controlled by bedrock and associated shallow till deposits. Portions of this landscape that have relatively deep soils and lodgepole pine/buffaloberry/showy aster (C6) or lodgepole pine/buffaloberry/twinflower (C19) v.t.s resemble PT1. Overall however, PT1 surficial materials are considerably deeper, topography is more gently sloping without sharp breaks, and the vegetation cover has considerably less lodgepole pine/juniper/bearberry (C3). The PT5 Ecosite is also characterized by a complex landscape pattern but has more gentle topography, and deeper till, with an associated dry > wet pattern of soil and vegetation.

PT4 - PATRICIA 4 ECOSITE

Ecosite Concept

The PT4 Ecosite occurs on ridged moraine or morainal blankets overlying ridged bedrock.

Table 312 Pedon (Alberta 1979 No. 21) description of an Eluviated Eutric Brunisol, lithic phase, of the PT3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: PT3.

LOCATION: MILITARY GRID REF. 11 UNJ 3435 6498; NTS MAP AREA 83C 13.

CLIMATE: 1150 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS GOOD RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 9 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=SJ9124=VTN=C3=.

SOIL SITE: PARENT MATERIAL 1: COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN; PARENT MATERIAL 2: SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), MORAINAL (TILL), CONGLOMERATE AND LIMESTONE AND QUARTZITE; PARENT MATERIAL 3: RESIDUAL; LANDFORM CLASSIFICATION: MORAINAL, VENEER; SLOPE: 16% COMPLEX SLOPE OF CLASS 6 (16-30%), FACING SOUTHEAST AND SOUTH, SITE AT MIDDLE POSITION; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; VERY STONY; MODERATELY ROCKY.

SPECIAL NOTES: SSN=DA9139=APN=01S-112=PCF=1GR,1ST(2)3GR,3CB,3ST(3-6)=LPM=EV/MV/RR=TRACE OF AH AT TOP BM=ROOT MATERIAL STAINING AROUND STONES TOP OF CK=LIME PENDANTS IN CK=NO VISIBLE CLAY SKINS=DATE=SEPT.16,1979=

L: 2 TO 0 CM, RANGE 1 TO 3 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/1; FEW, MEDIUM ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

BM: 0 TO 15 CM, RANGE 11 TO 21 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 4/4, MATRIX DRY 10YR 6/4; SANDY LOAM; VERY WEAK, FINE TO MEDIUM, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE AND MEDIUM ROOTS; 10% GRAVELLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2AE: 15 TO 27 CM, RANGE 7 TO 15 CM; HORIZON DRY; MATRIX DRY 10YR 7/4; FINE SANDY LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; SLIGHTLY HARD CONSISTENCE; ABUNDANT, MICRO AND VERY FINE ROOTS; COMMON, MICRO PORES; 50% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2AB: 27 TO 45 CM, RANGE 16 TO 22 CM; HORIZON DRY; MATRIX DRY 10YR 6/4, MATRIX DRY 10YR 6/6; FINE SANDY LOAM; WEAK TO MODERATE, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; HARD CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE ROOTS; MANY, MICRO PORES; 80% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2BTJ: 45 TO 62 CM, RANGE 12 TO 21 CM; HORIZON DRY; MATRIX DRY 7.5YR 5/6, MATRIX DRY 10YR 5/6; SANDY LOAM; MODERATE TO STRONG, MEDIUM TO COARSE, SUBANGULAR BLOCKY STRUCTURE; HARD CONSISTENCE; PLENTIFUL, MICRO ROOTS; MANY, MICRO PORES; VERY WEAK EFFERVESCENCE; 80% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2CK: 62 TO 87 CM; HORIZON DRY; MATRIX DRY 10YR 6.5/3; SANDY LOAM; MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE PSEUDO; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; VERY HARD CONSISTENCE; STRONG EFFERVESCENCE; MODERATELY CALCAREOUS; 50% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
L	5.2	34.40							
BM	6.3	1.20		11.7		10.0	0.3	0.1	0.3
2AE	6.1	0.40		5.4		4.8	0.6	-.1	0.1
2AB	6.3	0.20		4.5		3.9	0.6	-.1	0.1
2BTJ	6.7	0.50	0.1	9.1		10.2	1.5	-.1	0.2
2CK	7.3		11.0						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
L				
BM	0.1		0.0	
2AE				
2AB				
2BTJ				
2CK				

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS % PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	% OF SAMPLE V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
L															
BM										48		48	4		
2AE					5	10	13	22	10	60		33	7		
2AB					5	9	13	21	7	55		39	6		
2BTJ					5	13	16	15	6	55		27	18		1.90
2CK	99	82	63	56	9	11	15	18	7	60		31	9		2.20

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
L													
BM	35.4		7.2										
2AE													
2AB	19.9		3.1										
2BTJ	27.1		6.6										
2CK	16.3		3.2			11.0	14.0					12	07

Table 313 Stand (SJ9124) illustrating the lodgepole pine/juniper/bearberry (C3) v.t. of the PT3 Ecosite

TREE LAYER	
Picea glauca	02
Pinus contorta	30
TALL SHRUB LAYER	
Picea glauca	.5
Pinus contorta	01
Pseudotsuga menziesii	.5
SHRUB LAYER	
Amelanchier alnifolia	02
Juniperus communis	20
Juniperus horizontalis	.5
Picea glauca	01
Pinus contorta	10
Pseudotsuga menziesii	02
Rosa acicularis	05
Shepherdia canadensis	15
Spiraea lucida	04
HERB-DWARF SHRUB LAYER	
Anemone multifida	.5
Antennaria nitida	.5
Arctostaphylos uva-ursi	55
Aster conspicuus	02
Campanula rotundifolia	.5
Carex spp.	01
Elymus innovatus	07
Fragaria virginiana	02
Lathyrus ochroleucus	.5
Lilium philadelphicum	.5
Linnaea borealis	05
Pyrola asarifolia	01
Pyrola secunda	01
Solidago decumbens	01
BRYOID LAYER	
Buellia papillata	.5
Cetraria ericetorum	.5
Cladonia cariosa	.5
Cladonia pyxidata	.5
Dicranum polysetum	.5
Drepanocladus uncinatus	.5
Grimmia calyptrata	.5
Lecanora frustulosa	.5
Lecanora melanophthalma	.5
Lecidea tessellata	.5
Leskeela nervosa	.5
Orthotricum anomalum	.5
Orthotrichum speciosum	.5
Parmelia taractica	.5
Peltigera aphthosa	.5
Peltigera polydactyla	.5
Physconia muscigena	.5
Pylaisiella polyantha	.5
Tortula ruralis	.5
Xanthoria elegans	.5
EPIPHYTES	
Cetraria pinastri	.5
Hypogymnia enteromorpha	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The moraines consist of calcareous, medium textured till (Till C). The dominant soils are Orthic and Eluviated Eutric Brunisols and Brunisolic Gray Luvisols. Vegetation cover, distinguishing PT4 from other PT Ecosites, is dominated by the aspen/hairy wild rye-peavine (C16) v.t.

The PT4 Ecosite is the least extensive Patricia Ecosite and is commonly found on broad valley bottom benchlands throughout the Montane Ecoregion in the lower Athabasca, Snake Indian, and Fiddle River valleys in Jasper. It has not been mapped in Banff but is known to occur outside the park, adjacent to the park boundary at Devil's Gap.

Geomorphology

The PT4 Ecosite is typified by ridged moraines or morainal blankets overlying ridged bedrock. These moraines are comprised of calcareous, medium textured till and include relatively extensive areas of the low lime, sandy loam textured phase of Till C around Pyramid Lake and Tekarra Creek. Tracts mapped at PT4 in other areas are characterized by higher lime, and loam to silt loam Till C materials. Calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) is a significant constituent of PT4 tracts located along the erosional scarp of the Snake Indian River. Veneers of calcareous, medium textured eolian material (Eolian material A) or altered, medium textured eolian material (Eolian material B) occur sporadically. Where present, these very thin eolian materials add carbonates to the soil surface or promote development of Bm horizons in the upper sola respectively.

Topographically, the PT4 Ecosite displays a series of subparallel ridges of low relief when compared to the PT3 Ecosite. Breaks in slope are subtle, hence ridge crests and inter-ridge depressions are broad with gentle slopes. Internally, slopes face in several directions but overall, PT4 tracts have southerly aspects. On benchlands, slopes normally range from 5 to 30%. Near erosional escarpments and on lower valley walls, ridged surfaces are superimposed on steeper inclined slopes ranging to 70%. In a few instances, tracts with linear slopes were mapped. Rarely does bedrock outcrop on PT4 although thin morainal veneers do exist, usually adjacent to PT3 tracts. One tract of PT4+R was mapped.

Soils

Various soils of the PT4 Ecosite are genetically similar and display varying degrees of eluvial (Ae) horizon and luvisolic development. Orthic and Eluviated Eutric Brunisols and Brunisolic Gray Luvisols dominate PT4 and are characterized by thin sola developed under well drained conditions. These soils have weak textural B horizons, some with sufficient pedogenic clay film development to be Bt horizons, occurring at or below the till-eolian material interface. Iron, aluminum, and humus enriched Bm horizons, developed in the Eolian material B veneers, often overlie the textural B horizons. These upper sola Bm

horizons are absent on the accessory Orthic Gray Luvisols. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly expressed in the absence of Eolian material B. In some localities, surface erosion or deposition inhibits Ae development. The pedon chosen to characterize PT1 (Table 310) illustrates Eluviated Eutric Brunisols of the PT4 Ecosite.

Wet soils and associated vegetation occur rarely on PT4 and only in small, unusually deep depressions. Local occurrences of Orthic and Eluviated Dystric Brunisols are associated with low lime till. Cumulic Regosols occur rarely and are associated with veneers of calcareous, medium textured eolian material (Eolian material A). Lithic soil phases occur infrequently and are associated with morainal veneers. In aggregate, the above group of soils occupies only a minor amount of the PT4 landscape.

Vegetation

The PT4 Ecosite is dominated by the aspen/hairy wild rye-peavine (C16) v.t. Factors affecting the occurrence of C16 as opposed to lodgepole pine/buffaloberry/showy aster (C6) or lodgepole pine/buffaloberry/twinflower (C19) are not well understood. A plot illustrating the C16 v.t. on PT4 is described in Table 314 and shown in Plate 154.

Intimately intermingled with the C16 v.t. are stands of lodgepole pine/buffaloberry represented mainly by the C6 v.t. Landscape segments with lodgepole pine may constitute up to 30% of some PT4 tracts. Shrubby cinquefoil/bearberry/northern bedstraw (L1) occurs occasionally on relatively steep, unstable slopes. Montane wet v.t.s occur rarely and only in small depressions in the landscape.

Discussion

The PT4 Ecosite is unique among Ecosites of the Montane Ecoregion because of its relatively limited areal extent and a landform-soil-vegetation combination that appears to be more abundant in the boreal forest to the east of Banff and Jasper. Landform and soil characteristics of PT1 and PT4 Ecosites are nearly identical but the vegetation of PT1 is dominated by lodgepole pine/buffaloberry/showy aster (C6) and lodgepole pine/buffaloberry/twinflower (C19), whereas PT4 is characterized by the C16 v.t.

Table 314 Stand (JE9177) illustrating the aspen/-hairy wild rye-peavine (C16) v.t. of the PT4 Ecosite.

TREE LAYER	
Populus tremuloides	40
SHRUB LAYER	
Picea glauca	.5
Pseudotsuga menziesii	.5
Shepherdia canadensis	15
HERB-DWARF SHRUB LAYER	
Achillea millefolium	01
Arctostaphylos uva-ursi	03
Aster conspicuus	.5
Aster spp.	.5
Bromus spp.	.5
Cerastium arvense	.5
Elymus innovatus	10
Fragaria virginiana	.5
Galium boreale	.5
Gentiana spp.	.5
Hedysarum alpinum	01
Juniperus communis	.5
Lathyrus ochroleucus	04
Phleum pratense	02
Poa pratensis	15
Pyrola secunda	.5
Rosa acicularis	05
Trifolium spp.	01
Trisetum spicatum	05
Vaccinium vitis-idaea	01
Vicia americana	.5
BRYOID LAYER	
Amblystegium serpens	.5
Brachythecium spp.	.5
Bryum spp.	.5
Drepanocladus uncinatus	.5
Leptobryum pyriforme	.5
Peltigera canina	.5
Pylaisiella polyantha	.5
EPIPHYTES	
Arthonia patelulata	.5
Caloplaca holocarpa	.5
Lecanora impudens	.5
Leptogium spp.	.5
Physcia adscendens	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

PT5 - PATRICIA 5 ECOSITE

Ecosite Concept

The PT5 Ecosite encompasses a landscape pattern consisting of approximately 60% dry (well drained, mesic) and 40% wet (poorly to very poorly drained, hygric to hydric) segments. Overall, the landform is ridged moraine consisting of calcareous, medium textured till (Till C) but inter-ridge depressions are frequently mantled by shallow organic deposits (horizontal fens). Dry segments are dominated by Orthic and Eluviated Eutric Brunisols and Brunisolic Gray Luvisols under the lodgepole pine/buffaloberry/showy aster (C6), lodgepole pine/feathermoss (C11), or lodgepole pine/buffaloberry/twinflower (C19) v.t.s. Wetland segments are dominated by Rego Gleysols and Terric Mesisols under black spruce-lodgepole pine/willow/sedge (C8) and spruce/Labrador tea/brown moss (O11) v.t.s. PT5 is common on broad benchlands throughout the Montane. It is most extensive in Jasper and of limited extent in Banff.

Geomorphology

The PT5 Ecosite is characterized by ridged moraine consisting of calcareous, medium textured till (Till C) including the low lime, sandy loam textured phase of Till C in the Athabasca and Miette River valleys above Jasper townsite. Calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) is a common landform constituent of PT5 tracts situated near river channels and their attendant glaciofluvial, glaciolacustrine, and steeply sloping erosional landforms. Examples of PT5 tracts containing significant amounts of Ice Contact Stratified Drift B occur in the Athabasca River valley below Mount Kerkeslin and in the lower Snake Indian and Rocky River valleys in Jasper.

Inter-ridge depressions are invariably wet and usually thinly mantled by moderately well to well decomposed peat derived primarily from sedges and brown mosses (e.g. *Tomenthypnum nitens* and *Aulacomnium palustre*) and occasionally, wood fragments. These organic deposits are usually underlain, within the control section, by till or ice contact stratified drift, occasionally by veneers of calcareous fluviolacustrine or fluvial materials. Wetland and organic terrain classifications (Zoltai et al. 1975, C.S.S.C. 1978b, Tarnocai 1980) do not adequately handle PT5 wetland segments. Even though they are usually forested, the organic material is considered to be fen peat, recognizing that the fen vegetation has been succeeded by forest. Where the peat is >40 cm thick, the landform is classified as a horizontal fen (C.S.S.C. 1978b).

Topographically, the PT5 Ecosite displays a series of subparallel ridges. Internal relief is relatively low compared to the PT3 Ecosite, slope breaks are subtle and ridge crests and depressional areas are broad with gentle slopes. Slopes normally range from 5 to 30% overall, although slopes of <5% are common on depressional segments. Hummocky topography with irregularly distributed, gently sloping depressions and knolls also occur, particularly where ice contact stratified drift is a significant constituent. Occasionally, morainal blankets and veneers accompanied by a few bedrock outcrops comprise the mineral landform component of those tracts mapped as PT5 and PT5 + R that are surrounded by PT3 tracts.

Veneers of calcareous, medium textured eolian material (Eolian material A) or altered, medium textured eolian material (Eolian material B) occur sporadically across both PT5 segments. Where present, Eolian material B is generally very thin and promotes development of upper sola Bm horizons. Eolian material A is common on PT5 tracts located adjacent to TA3 tracts (e.g. Rocky River valley near Talbot Lake in Jasper) and it significantly modifies soil development by adding calcareous material to the soil surface.

Soils

Soils of the PT5 Ecosite are distributed in a pattern governed by drainage conditions. Soils of the well drained, upland segments display varying degrees of eluvial (Ae) horizon and luvisolic development. The dominants are Orthic and Eluviated Eutric Brunisols and Brunisolic Gray Luvisols. These have weak textural B horizons, some with sufficient pedogenic clay film development to be Bt horizons, occurring at or near the till-eolian interface. Iron, aluminum, and humus enriched Bm horizons, developed in the Eolian material B veneers, often overlie the textural B horizons. The upper sola Bm horizons are absent in the accessory Orthic Gray Luvisols. Eluvial (Ae) horizons are discontinuous across the landscape and are often only weakly expressed in the absence of Eolian material B. In some localities, surface erosion or deposition inhibits Ae development. Soils occurring in small amounts on upland areas are Orthic and Eluviated Dystric Brunisols occurring locally on low lime till and Cumulic Regosols on recent Eolian material A deposits. The pedon chosen to characterize PT1 (Table 310) illustrates Eluviated Eutric Brunisols on dry segments of PT5.

A variety of pedogenically related soils occurs on the poorly to very poorly drained, depressional segments of PT5. These are best represented by the Rego Gleysol and Terric Mesisol Subgroups. Mineral layers are usually strongly gleyed reflecting high water tables and long periods of saturation, conditions that inhibit pedogenic horizonation. Orthic Gleysols are important accessory soils in localities with shorter periods of saturation such as in depressions with drainage outlets and along raised margins of depressions. Appropriate moisture, nutrient, and vegetation conditions have resulted in the accumulation of varying thicknesses of fen peat on the depressional soils. Terric Mesisols occur where the peat is >40 cm thick. Other Organic soils with subdominant humic or fibric layers, gleyed Regosols, and Humic Gleysols occur in minor amounts. Humic Gleysols and gleyed Humic Regosols are important on tracts that are receiving or recently received Eolian material A (e.g. lower Rocky River valley near Talbot Lake in Jasper). These generally have Ahk horizons, occasionally underlain by Bmk or Bg horizons. The pedon described in Table 113 for wet segments of the Baker Creek 1 (BK1) Ecosite also illustrates Rego Gleysols of PT5 wet depressional segments.

Vegetation

Vegetation of the PT5 Ecosite relates to the dry > wet pattern of soils. The lodgepole pine/buffaloberry/showy aster (C6), lodgepole pine/feathermoss (C11), and lodgepole pine/buffaloberry/twinflower (C19) v.t.s dominate upland segments; black spruce-lodgepole pine/willow/sedge (C8) and spruce/Labrador tea/brown moss (O11) the wetland depressions.

The C6, C11, and C19 v.t.s reflect the varying stages of regeneration after a fire in the Montane Ecoregion. A plot illustrating the C11 v.t. on dry segments of PT5 is described in Table 315. Lodgepole pine/green alder/feathermoss (C10), an accessory v.t., occurs at higher elevations on cooler, more moist northerly aspects in Jasper. Also, episodic seepage is sometimes associated with C10. White spruce/buffaloberry/fern moss (C26) is a v.t. occurring in minor amounts on tracts that have veneers of Eolian material A.

Table 315 Stand (LC9179) illustrating the lodgepole pine/feathermoss (C11) v.t. of dry upland segments of the PT5 Ecosite.

TREE LAYER	
Picea glauca	15
Pinus contorta	25
TALL SHRUB LAYER	
Picea glauca	20
SHRUB LAYER	
Juniperus communis	02
Picea glauca	08
HERB-DWARF SHRUB LAYER	
Elymus innovatus	04
Hedysarum spp.	03
Linnaea borealis	22
Pyrola secunda	03
Salix spp.	03
Shepherdia canadensis	.5
BRYOID LAYER	
Campylium polygamum	03
Cladonia pocillum	.5
Cladonia pyxidata	01
Distichium capillaceum	.5
Ditrichum flexicaule	.5
Drepanocladus uncinatus	15
Hylocomium splendens	15
Hypnum revolutum	02
Peltigera canina	04
Pleurozium schreberi	10
Thuidium abietinum	20
EPIPHYTES	
Ramalina sinensis	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The C8 and O11 v.t.s reflect the high water tables and seepage conditions of depressional localities. A plot illustrating the C8 v.t. on wet segments of PT5 is described in Table 316. A minority of depressions are essentially treeless and are covered by dwarf birch-shrubby cinquefoil-willow/brown moss (S1) or water sedge-beaked sedge (H11). The H11 v.t. occurs in very poorly drained depressions and is usually associated with ponding throughout most of the summer. Occasionally, white spruce/prickly rose/horsetail (C4) and willow/horsetail (S7) are found on depressional segments.

Table 316 Stand (LC9178) illustrating the black spruce-lodgepole pine/willow/sedge (C8) v.t. of wet depressional segments of the PT5 Ecosite.

TREE LAYER	
Larix laricina	05
Picea glauca	05
Picea mariana	20
TALL SHRUB LAYER	
Picea glauca	10
Picea mariana	05
SHRUB LAYER	
Ledum groenlandicum	10
Picea glauca	05
Salix myrtillifolia	10
HERB-DWARF SHRUB LAYER	
Anemone spp.	.5
Arctostaphylos rubra	04
Arctostaphylos uva-ursi	01
Carex vaginata	15
Elymus innovatus	.5
Gentiana amarella	.5
Geocaulon lividum	02
Ledum groenlandicum	10
Linnaea borealis	05
Orchis rotundifolia	01
Picea glauca	.5
Pyrola asarifolia	.5
Salix myrtillifolia	05
Equisetum arvense	03
Equisetum scirpoides	04
BRYOID LAYER	
Aulacomnium palustre	40
Bryum pseudotriquetrum	.5
Campylium polygamum	.5
Cladonia pyxidata	01
Distichium capillaceum	.5
Ditrichum flexicaule	.5
Encalypta procera	.5
Hylocomium splendens	.5
Isopterygium pulchellum	.5
Peltigera rufescens	02
Ptilium crista-castrensis	05
Thuidium abietinum	.5
Tomenthypnum nitens	.5
Tortella tortuosa	.5
EPIPHYTES	
Caloplaca aurantiaca	.5
Lecanora hagenii	.5
Physcia adscendens	.5
Physconia detersa	.5
Ramalina sinensis	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The PT5 Ecosite encompasses a landscape pattern consisting of well drained upland segments, similar to PT1, separated by poorly to very poorly drained wetland depressions. The proportion of wet depressions on PT5 tracts commonly ranges from 30 to 50%. Map presentation of PT5 tracts at scales larger than 1:50,000 is invalid because these segments would become mappable as separate Ecosites. The PT5 Ecosite most closely resembles the BK1 and BK4 Ecosites but is distinguished because it occurs in the Montane Ecoregion rather than the Lower Subalpine which has different vegetation cover reflecting the higher elevations.

RD - REDOUBT ECOSECTION

The Redoubt (RD) Ecosection encompasses steep, usually linear, colluvial landforms comprised of noncalcareous, medium textured colluvium (Colluvium B) in the Alpine Ecoregion of Banff and Jasper. It occurs on or below steep, rocky walls in areas that are geologically dominated by Miette Group or noncalcareous Mesozoic strata.

Dystric and Sombric Brunisols, Regosols, and Humic Regosols characterize the soils of RD. These well drained soils reflect the acidic, medium textured parent material. The vegetation component is characterized by mountain avens and heath tundra. Only one Ecosite (RD1) is recognized within the RD Ecosection. Its general features are outlined in Table 317. Figs. 42 and 54 show schematically the physiographic position of RD1 on the landscape in relation to other Ecosites.

RD1 - REDOUBT 1 ECOSITE

Ecosite Concept

The Alpine Ecosite, RD1, encompasses blankets and veneers comprised of noncalcareous, medium textured colluvium (Colluvium B) overlying bedrock on steep valley walls. The soil component is dominated by Orthic Dystric Brunisols, Orthic Sombric Brunisols, Orthic Regosols, and Orthic Humic Regosols. The vegetation component is dominated by the mountain avens-snow willow-moss campion (H1) v.t., with smaller amounts of the heather-everlasting (L5) v.t.

Geomorphology

The RD1 Ecosite occurs on blankets and veneers comprised of noncalcareous, medium textured colluvium (Colluvium B) overlying inclined bedrock on steep valley walls. Source bedrock is Miette Group in the Main Ranges or noncalcareous Mesozoic strata in the Front Ranges. Colluviation, including soil creep and avalanche, occurs locally. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically and are most abundant on RD1 tracts of western Banff and southwestern Jasper. Erosional and colluvial processes have removed or incorporated most of the wind blown accumulation. Rubble that lacks fine earth material for soil development (fragmental) is common on some RD1 tracts, particularly those occurring below steep rock walls.

Topographically, RD1 displays long, linear, inclined slopes commonly ranging from 45 to 70%. Tracts mapped as RD1 with complex topography have linear slopes whose continuity is broken by one or more steep bedrock escarpments. Colluvial veneers dominate on those tracts mapped as RD1X. Exposed bedrock dominates on RD1+R tracts. Tracts with failed slopes (RD1F), including failure of the unconsolidated material and partial failure of underlying bedrock, occur occasionally.

Soils

Soil development and distribution reflects the degree and intensity of surface colluviation and, to a lesser extent, avalanching. Orthic Dystric Brunisols, Orthic Sombric Brunisols, Orthic Regosols, and Orthic Humic Regosols are the dominant soils. Orthic Dystric Brunisols occupy localities where surface modification is weak and eluvial (Ae) horizon development is inhibited or destroyed. Orthic Sombric Brunisols and Orthic Humic Regosols occupy localities where humus accumulations in the upper sola (Ah horizons) are evident. Locally, colluviation has physically thickened surface organo-mineral horizons. Orthic Regosols occur where geomorphic activity is frequent and intense, such as on unvegetated rubbly sites.

Soils of the RD1 Ecosite are well drained and reflect in their development, the acidic,

Table 317 General features of the Redoubt 1 (RD1) Ecosite.

Ecosite	Landform	Soils	Vegetation
RD1	Colluvium B; blanket, veneer	Dystric Brunisol, Sombric Brunisol, Regosol, Humic Regosol	mountain avens tundra, heath tundra

Table 318 Pedon (Alberta 1978 No. 54) description of an Orthic Regosol of the RD1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC REGOSOL. SOIL MAP UNIT: NOTATION: RD1.

LOCATION: MILITARY GRID REF. 11 UNH 6870 370; NTS MAP AREA 82O SE.

CLIMATE: 2400 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 2 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JC8079*VTH=L7*VEGETATION UNCHARACTERISTIC.BIT ON MOIST SIDE OF CONCEPT*.

SOIL SITE: PARENT MATERIAL 1: SHATTERED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), COLLUVIAL, SHALE; LANDFORM CLASSIFICATION: ACTIVE COLLUVIAL, GRAVELLY, SOLIFLUCTED, VENEER; SLOPE: 60% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING NORTHEAST, SITE AT MIDDLE POSITION, STRONGLY MOUNDED MICROTOPOGRAPHY,400 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, MODERATELY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY.

SPECIAL NOTES: SSN=SC8034*APH=010-162*PCF=1AG(1)1AG,1AC(2-3)*LFH=CV/BI*SOIL IS DEVELOPED FROM SOFT CARBONIFEROUS SHALES WHICH CONTRIBUTE TO ORGANIC CARBON*SURFACE HORIZON IS THEREFORE AC% RATHER THAN ORGANIC*LFH=CV/BI-S*

AC1: 0 TO 6 CM, RANGE 4 TO 10 CM; MATRIX MOIST 10YR 2/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; FEW, VERY FINE PORES; ANGULAR GRAVELLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY; MEDIUM ACID 5.6-6.0 FIELD PH.

AC2: 6 TO 37 CM, RANGE 28 TO 35 CM; MATRIX MOIST 10YR 2/1; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; WEAK, FINE, GRANULAR SECONDARY STRUCTURE PSEUDO; VERY FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; FEW, VERY FINE PORES; 10% ANGULAR GRAVELLY AND ANGULAR COBBLY COARSE FRAGMENTS; WAVY, DIFFUSE HORIZON BOUNDARY; STRONGLY ACID 5.1-5.5 FIELD PH.

C: 37 TO 106 CM; MATRIX MOIST 10YR 2/1; COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; WEAK, FINE, GRANULAR SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; MODERATELY POROUS, VERY FEW, FINE PORES; 10% ANGULAR GRAVELLY AND ANGULAR COBBLY COARSE FRAGMENTS; STRONGLY ACID 5.1-5.5 FIELD PH.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
AC1	5.3	26.50	51.0		22.1	5.9	~.1	0.5
AC2	5.0	14.60	33.9		12.7	5.8	~.1	0.2
C	4.8	9.00	21.7		7.5	2.4	~.1	0.1

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
AC1					1	2	3	7	5	18		58	24	
AC2	99			72	1	1	2	8	7	19		60	21	
C	99	85	69	56	13	15	9	10	6	53		38	9	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AC1													
AC2		18.2	10.8									A0	09
C		12.4	6.4									24	10

medium textured, parent material. The Brunisolic soils have well developed B horizons. Orthic Sombric Brunisols and Orthic Humic Regosols have thick Ah horizons. Orthic Dystric Brunisols and Orthic Regosols may have thin Ah horizons. Accessory soils, Cumulic Regosols and Cumulic Humic Regosols, occur occasionally. Also turbic soil phases occur occasionally on some RD1 tracts. Lithic soil phases dominate those tracts mapped as RD1X. A pedon illustrating Orthic Regosols of RD1 is described in Table 318. This pedon was sampled on a northeast slope near the headwaters of Wigmore Creek in Banff. The soil is developed on colluvium derived from carbonaceous shales of the Kootenay Formation.

Vegetation

Distribution of vegetation on RD1 reflects the degree of colluvial activity, exposure, and elevation. The mountain avens-snow willow-moss campion (H1) and heather-everlasting (L5) v.t.s. are dominant. The H1 v.t. is most abundant but a few tracts are dominated by L5. Generally, H1 occurs at higher elevations than L5. Up to 15% krummholz and tree islands are included with L5 along lower boundaries of some RD1 tracts. White mountain heather-mountain avens-snow willow (L4) is an accessory v.t. that occurs in late snow lie areas. Mountain avens-kobresia-bearberry (H4) is another accessory v.t. that occurs at higher elevations

predominantly on southerly aspects in the Front Ranges. The arctic willow-cinquefoil (L7) and fleabane-valerian (H16) v.t.s occur in minor amounts on moister portions of RD1. Unvegetated portions, associated with rubbly colluvium and Regosolic soils on intensely geomorphically active sites, may constitute up to 50% of some RD1 tracts. A plot illustrating the heather-everlasting (L5) v.t. of RD1 is described in Table 319 and shown in Plate 155. This plot was described in the same RD1 tract as the pedon sample site described above in Table 318.

Table 319 Stand (JC8084) illustrating the heather-everlasting (L5) v.t. of the RD1 Ecosite.

HERB-DWARF SHRUB LAYER	
Anemone drummondii	.5
Antennaria lanata	04
Arenaria capillaris	.5
Artemisia norvegica	.5
Aster alpinus	01
Carex foenea	.5
Castilleja occidentalis	.5
Draba spp.	.5
Dryas octopetala	10
Erigeron aureus	.5
Erigeron peregrinus	.5
Festuca saximontana	.5
Juncus drummondii	.5
Luzula wahlenbergii	.5
Phleum pratense	.5
Phyllodoce glanduliflora	20
Poa alpina	.5
Potentilla diversifolia	02
Salix arctica	15
Sedum stenopetalum	.5
Stellaria spp.	.5
Trisetum spicatum	01
Vaccinium scoparium	10
Veronica alpina	.5
Selaginella densa	.5
BRYOID LAYER	
Brachythecium albicans	.5
Pohlia cruda	.5
Peltigera leucophlebia	.5
Peltigera rufescens	01
Polytrichum juniperinum	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

In landform surface expression, physiographic position and vegetation cover, RD1 resembles the Bow Summit 1 (BS1) and Tekarra 1 (TK1) Ecosites. However, unlike the Colluvium B of RD1, BS1 occurs on colluvial landforms consisting of calcareous, medium textured colluvium (Colluvium C), and TK1 occurs on noncalcareous, coarse textured colluvium (Colluvium A). Also, BS1 has neutral to alkaline rather than acid soils, and TK1 has similar soils to RD1 but the sola are thicker and the Bm horizons are better developed than RD1. The Whitehorn (WH1) Ecosites are the Upper Subalpine counterparts of RD1.

RK - ROCKY ECOSECTION

The Rocky (RK) Ecosection occurs in the Montane Ecoregion and is characterized by blankets of calcareous, fine textured glaciolacustrine material overlying hummocky and undulating slopes of calcareous glacial materials. The RK Ecosection is dominated by Luvisolic and Brunisolic soils and moist lodgepole pine forests.

The RK Ecosection is mapped only in Jasper. It occurs on valley floor benchlands above the Rocky River between Dromore Creek and the Athabasca River valley and in the Snake Indian River valley between the Shale Banks and Seldom Inn warden cabins.

The RK Ecosection is represented by only one Ecosite (RK1). General features of this Ecosite are outlined in Table 320. Fig. 46 shows the position of RK1 on the landscape.

RK1 - ROCKY 1 ECOSITE

Ecosite Concept

The RK1 Ecosite is characterized by blankets of calcareous, fine textured glaciolacustrine material overlying hummocky and undulating slopes of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). Well to moderately well drained Orthic and Brunisolic Gray Luvisols are more common than Eluviated Eutric Brunisols as the dominant soils on RK1. Representative v.t.s are lodgepole pine/buffaloberry/twinflower (C19) and lodgepole pine/Labrador tea (C29).

Geomorphology

The RK1 Ecosite is typified by blankets of calcareous, fine textured glaciolacustrine material overlying hummocky and undulating slopes of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). The glaciolacustrine deposits in the lower Rocky and Snake Indian River valleys are sediments deposited in proglacial lakes. Discontinuous, thin surficial veneers of altered,

Table 320 General features of the Rocky 1 (RK1) Ecosite.

Ecosite	Landform	Soils	Vegetation
RK1	Glaciolacustrine material; blanket	Luvisolic, Brunisolic	lodgepole pine forest

medium textured eolian material (Eolian material B) occur on some tracts of RK1. The surface expression of RK1 is dominantly undulating with slopes commonly ranging from 2 to 10%.

Soils

Well to moderately well drained Orthic and Brunisolic Gray Luvisols are more common than Eluviated Eutric Brunisols as the dominant soils on RK1. A feature common to these soils is the presence of textural B horizons, many with pedogenic clay film development sufficient to be Bt horizons; these horizons occur at or near the upper boundary of the glaciolacustrine material, whether or not it is overlain by Eolian material B. Within the parks, Bt horizons are best expressed in soils with glaciolacustrine deposits as parent materials. Iron, aluminum, and humus enriched Bm horizons tend to develop in Eolian material B veneers, where they are present. Orthic Gray Luvisols occur where the veneer is thin or absent. Orthic Eutric Brunisols are accessory soils that occur where eluvial (Ae) horizons are weakly expressed or absent. The pedon description in Table 263 for the dry portion of the Nashan 1 (NH1) Ecosite also illustrates Orthic Gray Luvisols of the RK1 Ecosite.

Vegetation

The RK1 Ecosite is dominated by the mesic lodgepole pine/buffaloberry/twinflower (C19) and lodgepole pine/Labrador tea (C29) v.t.s. The accessory v.t. lodgepole pine/feathermoss (C11) also occurs.

A vegetation plot description of a C19 v.t. on RK1 is illustrated in Table 321.

Discussion

The RK1 Ecosite has the same characteristics as the dry portion of the Nashan 1 (NH1) Ecosite. The two Ecosites are distinguished because NH1 has a complex wet > dry landscape pattern whereas RK1 is characterized by a dry landscape pattern. The RK1 Ecosite is the Montane counterpart of the Lower Subalpine Spray 1 (SP1) Ecosite. A good example of RK1 occurs between Rocky River and Makwa Creek, near their confluence.

Table 321 Stand (SJ9019) illustrating the lodgepole pine/buffaloberry/twinflower (C19) v.t. of the RK1 Ecosite.

TREE LAYER	
Picea glauca	12
Pinus contorta	08
TALL SHRUB LAYER	
Picea glauca	01
SHRUB LAYER	
Juniperus communis	02
Ledum groenlandicum	01
Picea glauca	02
Potentilla fruticosa	.5
Rosa acicularis	01
Salix glauca	.5
Shepherdia canadensis	07
HERB-DWARF SHRUB LAYER	
Arctostaphylos uva-ursi	01
Arnica cordifolia	01
Calypso bulbosa	03
Cornus canadensis	03
Elymus innovatus	05
Lathyrus ochroleucus	02
Linnaea borealis	10
Picea glauca	05
Pinus contorta	01
Pyrola secunda	.5
Vaccinium caespitosum	.5
Vaccinium vitis-idaea	02
BRYOID LAYER	
Cetraria nivalis	.5
Cladonia cariosa	.5
Cladonia coccifera	.5
Cladonia cornuta	.5
Cladonia gonecha	.5
Cladonia gracilis	.5
Cladonia mitis	.5
Cladonia rangiferina	.5
Dicranum brevifolium	03
Hylocomium splendens	70
Icmadophila ericetorum	.5
Lophozia spp.	.5
Peltigera aphthosa	03
Peltigera canina	.5
Pleurozium schreberi	10
Pohlia nutans	.5
Polytrichum juniperinum	.5
Ptilium crista-castrensis	.5
Stereocaulon spp.	01
Thuidium abietinum	.5
EPIPHYTES	
Alectoria sarmentosa	.5
Bryoria fremontii	.5
Cetraria pinastri	.5
Hypogymnia austerodes	.5
Letharia vulpina	.5
Parmelia sulcata	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5
Platismatia glauca	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

SB - SAWBACK ECOSECTION

The Sawback (SB) Ecosection encompasses steep, linear landforms comprised of calcareous, medium textured colluvium (Colluvium C) in the Lower Subalpine portion of the Subalpine Ecoregion in Banff and Jasper. It occurs on or below steep, rocky valley walls and is associated with calcareous strata. Varying type and degree of colluvial activity, aspect, exposure and lithology govern soil and vegetation development and distribution. The SB Ecosection is characterized by Regosolic and Brunisolic soils associated with heterogeneous avalanche complex vegetation, Engelmann spruce-subalpine fir forest, lodgepole pine forest, coniferous open forest, shrub-herb meadow, and grassland.

Five Ecosites (SB1, SB2, SB3, SB4, and SB5) are recognized within the SB Ecosection and are separated primarily on vegetational differences. Table 322 outlines the general features of the Ecosites. Fig. 51 shows SB1 and SB2 Ecosites on the landscape in relation to other Ecosites. Fig. 52 shows the position of SB5.

SB1 - SAWBACK 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, SB1, encompasses colluvial landforms comprised of calcareous, medium textured colluvium (Colluvium C). These exist as blankets overlying inclined bedrock and as aprons at major slope breaks. Snow avalanching is characteristic and affects both soil and vegetation. Perla and Martinelli (1975) discuss much of the scope of avalanching. The soil component of SB1 is dominated by Orthic Eutric Brunisols, Orthic Regosols, and Orthic and Cumulic Humic Regosols. Vegetation is distributed in a pattern governed by avalanching. Avalanched segments dominate and are characterized by a heterogeneous complex of v.t.s that include subalpine fir-willow (S2), willow-dwarf birch-shrubby cinquefoil (S10), hairy wild rye-wild strawberry-fireweed (H5), aspen/hairy wild rye-showy aster (C22) plus intergrades, collectively called Avalanche Complex 1. Forested strips and patches between avalanche tracks and fringing runout zones are subdominant and best represented by the Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/false azalea (C14) v.t.s.

Geomorphology

The SB1 Ecosite encompasses blankets and aprons comprised of calcareous, medium textured colluvium (Colluvium C). Frequent snow avalanches maintain the soil and vegetation characteristics on more than 50% of SB1 tracts. Avalanching of such areal extent usually occurs as coalescing unconfined avalanche paths or as runout zones below the length of a cliff. Gully-like, channeled avalanche tracks (chutes) are common as well.

Genetic material stability within SB1 tracts is greatest on portions unaffected by avalanching but the unconfined tracks are almost as stable. Together these components make up the majority of the area of SB1 tracts. Geomorphic instability is of two kinds. The first, erosion of unconsolidated material occurs, though infrequently, on steep avalanche starting zones and on walls of channelled tracks. It is usually evidenced by sparsely vegetated patches. The second, deposition, is a more common process and frequently includes material derived from bedrock exposures high on, or above the SB1 tract. Talus also occurs, its location and extent controlled by the cliffs above. Material carried by an avalanche is redistributed in the gentler runout zones. Colluvial material is modified by intermittent streams below couloirs and on avalanche runout zones. Fluvial deposits, occurring as thin veneers and as layers interbedded with colluvium, are medium textured with a high content of angular coarse fragments. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically on the subdominant unavalanched segment of the landscape. Rubble and blocks that lack fine earth material for soil development are common on some SB1 tracts, particularly those occurring below steep rock walls.

Topographically, SB1 displays long, linear, inclined slopes commonly ranging from 45 to 90%. Slopes <45% occur on avalanche runout zones. Surface form is controlled by deposition and underlying bedrock. The colluvial material is generally shallowest (veneers) at the tops of slopes and deepens downslope to form aprons. Colluvial aprons also occur below rock walls. Fans constructed by intermittent streams are often associated with

Table 322 General features of the Sawback (SB) Ecosites.

Ecosite	Landform	Soils	Vegetation
SB1	Colluvium C; blanket, apron	Brunisolic, Regosolic	Avalanche Complex 1 > Engelmann spruce-subalpine fir forest
SB2	Colluvium C; blanket, apron	Brunisolic, Regosolic	Engelmann spruce-subalpine fir forest
SB3	Colluvium C; blanket, apron	Brunisolic, Regosolic	lodgepole pine forest
SB4	Colluvium C; blanket, veneer > bedrock; inclined	Brunisolic, Regosolic	coniferous open forest > lodgepole pine forest, shrub-herb meadow
SB5	Colluvium C; blanket, veneer	Brunisolic, Regosolic	grassland

Figure 51 Landscape schematic showing the relationship of the Sawback (SB1, SB2) Ecosites to other Ecosites.

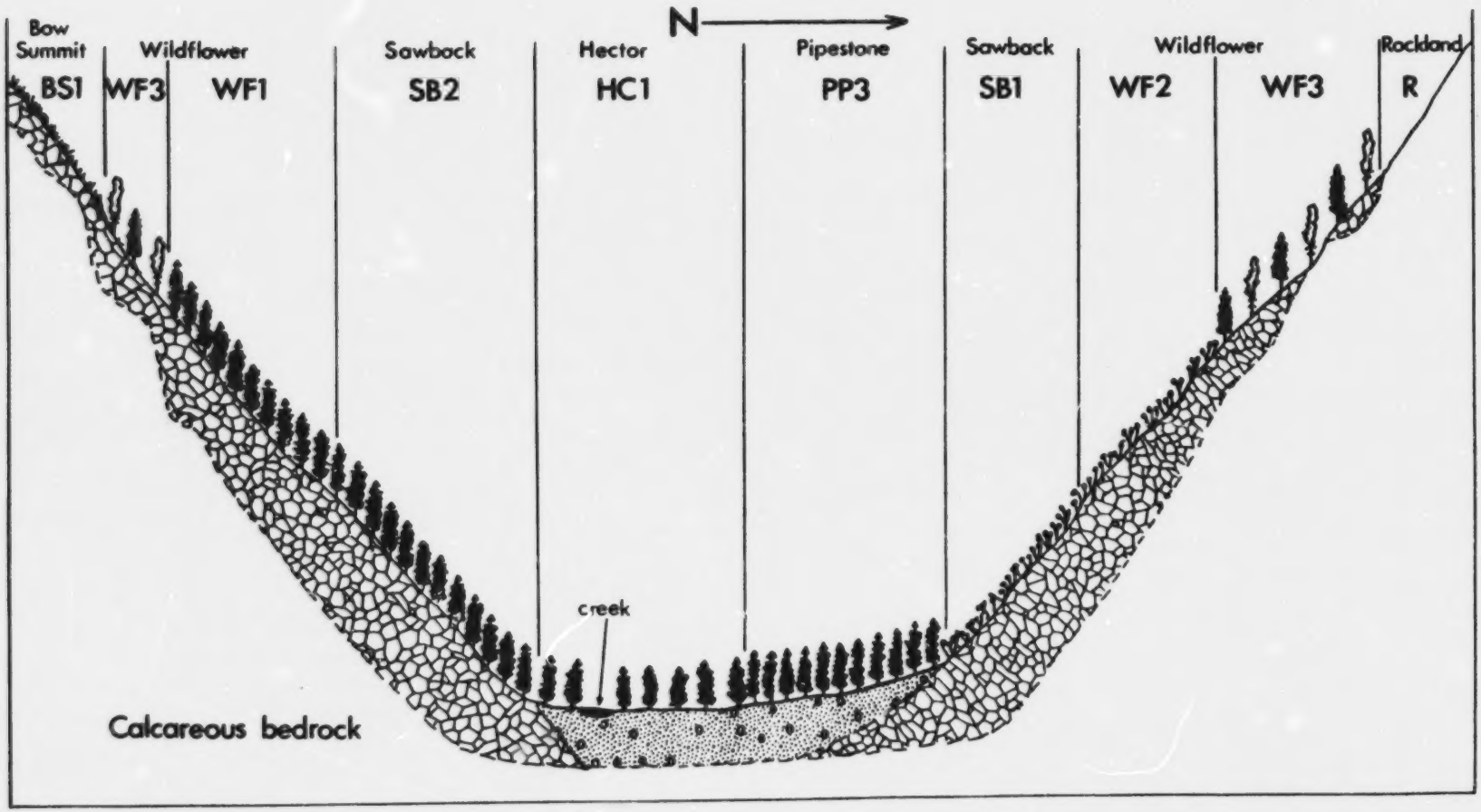


Table 323 Pedon (Alberta 1978 No. 93) description of a Cumulic Humic Regosol of the SB1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: CUMULIC HUMIC REGOSOL. SOIL MAP UNIT: NOTATION: SB1.

LOCATION: MILITARY GRID REF. 11 UNH 1070 6490; NTS MAP AREA 83C 2W.

CLIMATE: 1530 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 0 DEG(C) AT 80 CM IN SEPTEMBER.

VEGETATION: VPN=JC8086*VTN=C22*..

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), COLLUVIAL, SILTSTONE AND MUDSTONE AND LIMESTONE; LANDFORM CLASSIFICATION: ACTIVE COLLUVIAL, AVALANCHED, BLANKET; SLOPE: 65% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING SOUTHWEST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,500 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; VERY STONY; NONROCKY.

SPECIAL NOTES: SSN=BN8138*APN=010-200*RLU=15*SSC=MX*PCF=1AGR,1ACB(1)4AGR,B,1ST(2)6ABR,3ACB,1ST(3-11)*LFH=CB/RI*EVIDENCE FOR SOME FLUVIAL MODIFICATION IN PROFILE,ESPECIALLY HORIZONS 4 AND 7-10*

LFH: 0 TO 0 CM, RANGE 6 TO 13 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/1; ABUNDANT, VERY FINE AND FINE ROOTS; 10% ANGULAR GRAVELLY AND ANGULAR COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

AHK: 0 TO 11 CM, RANGE 9 TO 17 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/2; LOAM; VERY WEAK, FINE TO MEDIUM, GRANULAR STRUCTURE; LOOSE CONSISTENCE; ABUNDANT, VERY FINE AND FINE ROOTS; MODERATE EFFERVESCENCE; STRONGLY CALCAREOUS; 40% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

ACK1: 11 TO 25 CM, RANGE 9 TO 18 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/2; COARSE SANDY LOAM; VERY WEAK, FINE, GRANULAR STRUCTURE; LOOSE CONSISTENCE; ADUNDANT, VERY FINE AND MICRO ROOTS; STRONG EFFERVESCENCE; STRONGLY CALCAREOUS; 70% ANBULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

CK1: 25 TO 34 CM, RANGE 8 TO 11 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/2; SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; ABUNDANT, VERY FINE AND MICRO ROOTS; STRONG EFFERVESCENCE; STRONGLY CALCAREOUS; 80% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

AHBK1: 34 TO 44 CM, RANGE 9 TO 14 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/2; LOAM; VERY WEAK, FINE, GRANULAR STRUCTURE; LOOSE CONSISTENCE; ABUNDANT, VERY FINE AND MICRO ROOTS; MODERATE EFFERVESCENCE; STRONGLY CALCAREOUS; 70% ANBULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

ACK2: 44 TO 60 CM, RANGE 12 TO 20 CM; HORIZON DRY; MATRIX DRY 10YR 3/2; SILT LOAM; LOOSE CONSISTENCE; ABUNDANT, VERY FINE AND MICRO ROOTS; STRONG EFFERVESCENCE; STRONGLY CALCAREOUS; 70% ANGULAR GRAVELLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

CK2: 60 TO 105 CM, RANGE 39 TO 51 CM; HORIZON DRY; MATRIX DRY 10YR 4/3; COARSE SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, FINE AND MICRO ROOTS; STRONG EFFERVESCENCE; STRONGLY CALCAREOUS; 70% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FWAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

AHBK2: 105 TO 111 CM, RANGE 5 TO 7 CM; HORIZON DRY; MATRIX DRY 10YR 2/1; COARSE SANDY LOAM; VERY WEAK, FINE, GRANULAR STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, MICRO ROOTS; STRONG EFFERVESCENCE; STRONGLY CALCAREOUS; 70% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK3: 111 TO 122 CM, RANGE 9 TO 14 CM; HORIZON DRY; MATRIX DRY 10YR 4.5/3; SILT LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; FEW, MICRO ROOTS; MODERATE EFFERVESCENCE; STRONGLY CALCAREOUS; 70% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BMBK: 122 TO 126 CM, RANGE 0 TO 5 CM; HORIZON DRY; MATRIX DRY 10YR 6/4; SILT LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; FEW, MICRO ROOTS; STRONG EFFERVESCENCE; STRONGLY CALCAREOUS; 70% ANGULAR GRAVELLY AND ANBULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; BROKEN, ABRUPT HORIZON BOUNDARY.

CK4: 126 TO 141 CM; HORIZON DRY; MATRIX DRY 10YR 4/3; COARSE SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 70% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LFH	6.9	26.50	13.1
AHK	7.2	13.50	11.6
ACK1	7.4	4.00	31.9
CK1	7.4	1.60	38.3
AHBK1	7.3	9.00	14.5
ACK2	7.3	5.20	14.0
CK2	7.5	2.00	28.9
AHBK2	7.4	5.80	25.5
CK3	7.5	1.90	37.0
BMBK	7.5	1.90	7.7
CK4	7.6	0.40	50.8

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LFH				
AHK				
ACK1				
CK1				
AHBK1				
ACK2				
CK2				
AHBK2				
CK3				
BMBK	0.1		-.1	
CK4				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	% OF SAMPLE 50-2U SILT	% OF SAMPLE 2U CLAY	% OF SAMPLE 0.2U CLAY
LFH														
AHK					14	16	9	8	5	52		35	13	
ACK1					28	20	9	6	3	66		24	10	
CK1					28	28	8	4	2	70		23	7	
AHBK1					11	15	6	4	3	39		47	14	
ACK2					9	9	5	4	4	31		51	18	
CK2					16	20	9	5	4	54		36	10	
AHBK2					17	29	9	5	4	64		23	13	
CK3					6	11	8	8	6	39		49	12	
BMBK					2	3	2	6	11	24		68	8	
CK4					22	17	8	5	3	55		36	9	

minor gullies occurring upslope on avalanche tracks. Unvegetated colluvium, usually Talus (T), dominates those tracts mapped as SB1+T. Colluvial veneers dominate SB1X tracts.

Soils

Soil distribution and development on the SB1 Ecosite is related to genetic material stability as influenced by avalanching and supplementary processes. A variety of soils, best represented by Orthic Eutric Brunisols, Orthic Regosols, Orthic Humic Regosols and Cumulic Humic Regosols dominate SB1. These soils reflect varying degrees of colluvial and fluvial activity and organic matter incorporation. Orthic Eutric Brunisols occupy localities where surface modification by erosion and/or deposition is weak but sufficient to retard or destroy eluvial (Ae) horizons. On localities where geomorphic erosion is frequent and/or intense Orthic Regosols are common, and where accretion is dominant, Orthic and Cumulic Humic Regosols predominate. These localities are predominantly avalanche track centers. Orthic Regosols also occur on unvegetated rubbly sites.

Soils of SB1 Ecosites are rapidly to moderately well drained and reflect, in their development, the calcareous medium textured parent material. Orthic Eutric Brunisols have thin sola and weakly developed Bm or Bmk horizons. Orthic and Cumulic Humic Regosols have thick Ah horizons that have built up by a combination of organic matter additions to the surface and soil creep. Orthic Regosols and Orthic Eutric Brunisols may have thin Ah horizons. Eluviated Eutric Brunisols and Cumulic Regosols are accessory soils. Eluviated Eutric Brunisols occupy localities on the more stable forested segments of the landscape. Cumulic Regosols occupy localities still actively aggrading. Orthic Melanic Brunisols occur in minor amounts, as do lithic soil phases which dominate tracts mapped as SB1X. A pedon illustrating Cumulic Humic Regosols of SB1 is described in Table 323 and shown in Color Plate 64. This pedon was sampled on the west facing slope of Mount Wilson near Rampart Creek in Banff. There is some evidence of fluvial activity in this pedon as expressed by the variation in textures of the horizons.

Vegetation

Vegetation distribution on the SB1 Ecosite is governed by the frequency and intensity of snow avalanching. Avalanched segments dominate and are characterized by a heterogeneous complex of avalanche v.t.s including subalpine fir-willow (S2), willow-dwarf birch-shrubby cinquefoil (S10), hairy wild rye-wild strawberry-fireweed (H5), aspen/hairy wild rye-showy aster (C22) plus intergrades. Of these, S2 and H5 are most abundant, with S2 occupying the moist sites. The S10, H5, and C22 v.t.s occur in slightly drier conditions and are more abundant on southerly aspects. Intergrades among these v.t.s and the v.t.s occurring in minor amounts, such as juniper-willow (L2) and hairy wild rye-junegrass-bearberry (H14), are common. A plot illustrating the C22 v.t. on avalanched segments of SB1 is described in Table 324 and shown in Plate 156 and represents the vegetation at the pedon sample site described above in Table 323.

Table 324 Stand (JC8086) illustrating the aspen/hairy wild rye-showy aster (C22) v.t. of the SB1 Ecosite.

TALL SHRUB LAYER	
Populus balsamifera	09
Populus tremuloides	01
SHRUB LAYER	
Juniperus communis	01
Populus balsamifera	04
Populus tremuloides	15
Salix scouleriana	.5
HERB-DWARF SHRUB LAYER	
Achillea millefolium	02
Aster ciliolatus	02
Aster conspicuus	05
Castilleja miniata	02
Elymus innovatus	70
Epilobium angustifolium	02
Fragaria virginiana	03
Galium boreale	.5
Hedysarum sulphurescens	01
Heracleum lanatum	.5
Poa spp.	01
Rosa acicularis	05
Thalictrum venulosum	02
BRYOID LAYER	
Brachythecium groenlandicum	01
Peltigera rufescens	.5
Tortula norvegica	.5
Tortula ruralis	02

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Unavalanched or infrequently avalanched segments may constitute up to 50% of SB1 tracts and occur as forested strips and patches between avalanche tracks and on the fringe of avalanche runout zones. The Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/false azalea (C14) v.t.s are most abundant on these segments. Engelmann spruce-subalpine fir/rock willow/alpine bearberry (O12) is an accessory v.t. that occurs on avalanche track margins. Lodgepole pine/juniper/bearberry (C3), lodgepole pine/buffaloberry/showy aster (C6), and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) are v.t.s occurring in minor amounts .

Unvegetated portions, associated with rubbly colluvium and Regosolic soils on intensely, geomorphically active sites, constitute up to 50% of SB1 tracts, and up to 80% of tracts mapped as SB1+T.

Discussion

In terms of landform surface expression, physiographic position, and vegetation cover, SB1 resembles the Fairview 1 (FV1) Ecosite. However, in contrast to the calcareous Colluvium C of SB1, FV1 occurs on colluvial landforms consisting of noncalcareous, coarse textured colluvium (Colluvium A) and noncalcareous, medium textured colluvium (Colluvium B) and has acidic rather than neutral or alkaline soils. The other SB Ecosites are separated from SB1 because they have <50% of their landscape affected by snow avalanching and other vegetation differences as outlined in Table 322. The Wildflower 2 (WF2) Ecosite is the Upper Subalpine counterpart of SB1.

SB2 - SAWBACK 2 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, SB2, encompasses colluvial landforms comprised of calcareous, medium textured colluvium (Colluvium C). These exist as blankets overlying inclined bedrock on steep valley walls and as aprons at major slope breaks. Orthic and Eluviated Eutric Brunisols and Orthic Regosols are the dominant soils. Orthic Eutric Brunisols are most abundant. Vegetation is dominated by the Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/false azalea (C14) v.t.s.

Geomorphology

The SB2 Ecosite has relatively stable landforms typified by blankets and aprons comprised of calcareous, medium textured colluvium (Colluvium C) overlying inclined bedrock. Underlying bedrock is predominantly calcareous. Although veneers of altered, medium textured eolian material (Eolian material B) occur extensively in western Banff and southwestern Jasper, erosional and colluvial processes have removed or incorporated much of the wind blown accumulations that were likely associated with SB2. Till occasionally underlies colluvial material along lower, more gentle slopes of SB2 tracts. Thin fluvial deposits, generally calcareous, coarse, stratified fluvial material (Fluvial material B), occasionally overlie colluvium on avalanched portions of SB2A tracts.

Topographically, SB2 displays long, linear slopes commonly ranging from 45 to 90%. Slopes <45% and >90% occur occasionally. Surface form is controlled by deposition and underlying bedrock. Colluvial veneers over rock occur occasionally on SB2 tracts but dominate tracts mapped as SB2X. Tracts with failed slopes (mapped as SB2F), including failure of the unconsolidated material and partial failure of underlying bedrock, occur infrequently.

Soils

The well drained soils of the SB2 Ecosite reflect relatively stable geomorphic conditions. Orthic and Eluviated Eutric Brunisols and Orthic Regosols are dominant. Orthic Eutric Brunisols are most abundant. Eluviated Eutric Brunisols and Orthic Regosols dominate a few SB2 tracts. Orthic Eutric Brunisols occupy localities where surface modification is weak but sufficient to retard or destroy eluvial (Ae) horizons. Where geomorphic activity is not frequent or intense and veneers of altered, medium textured eolian material (Eolian material B) are present, Eluviated Eutric Brunisols and accessory Orthic Humo-Ferric Podzols may occur. Orthic Regosols and accessory Cumulic Regosols occupy localities where geomorphic activity is frequent, such as avalanche tracks. Orthic Melanic Brunisols occur in minor amounts as do lithic soil phases which dominate tracts mapped as SB2X. A pedon described in Table 325 is illustrative of Orthic Eutric Brunisols on SB2. This pedon was sampled on a tract of SB2 on a north facing slope below Goat's Eye in the Healy Creek valley of Banff. The Ae and Bm horizons of this profile are developed in an Eolian material B veneer.

Vegetation

Mature vegetation cover of the SB2 Ecosite indicates relatively stable geomorphic conditions. The Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/false azalea (C14) v.t.s are dominant. The C14 v.t. predominantly occurs on SB2 tracts on northerly aspects in western Banff and Jasper. Accessory v.t.s on SB2 include Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21), Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30), and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31). While C21 occurs on SB2 tracts in western Banff and western and northern Jasper, C30 and C31 usually occur in eastern Banff and Jasper. Tracts with 20 to 50% of their area modified by snow avalanching are mapped as SB2A. The avalanched portions have a variety of v.t.s such as subalpine fir-willow (S2). willow-dwarf birch-shrubby cinquefoil (S10), and Engelmann spruce-subalpine fir/rock willow/alpine bearberry (O12). Tracts mapped as SB2B have been modified by fire. A stand illustrating the C14 v.t. of SB2 is described in Table 326 and represents the vegetation at the pedon sample site described in Table 325.

Table 325 Pedon (Alberta 1978 No. 35) description of an Orthic Eutric Brunisol of the SB2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: SB2.

LOCATION: MILITARY GRID REF. 11 UNG 8840 6320; NTS MAP AREA 820 4E.

CLIMATE: 1860 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VTN=JE0130*VTN=C14*.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EOLIAN, ASH; PARENT MATERIAL 2: CHEMICAL AND PHYSICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), COLLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: COLLUVIAL, AVALANCHED, INCLINED; SLOPE: 50% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING NORTH, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY, 400 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, VERY RAPID SURFACE RUNOFF, SEEPAGE ABSENT; NONSTONY; NONROCKY.

SPECIAL NOTES: SSN*TAB141*APH=011-019*RLU=15*PCF*2AGR,2ACB,3AST(2-3)3AGR,3ACB,3AST(4)BAGR,3ACB(5)*LFH=CB/RI*

LF: 14 TO 0 CM, RANGE 11 TO 17 CM; MATRIX MOIST 10YR 2/2; ABUNDANT, FINE, RANDOM ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 2 CM, RANGE 0 TO 3 CM; MATRIX MOIST 10YR 5/4; SILT LOAM; VERY WEAK, VERY FINE TO FINE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MEDIUM, HORIZONTAL ROOTS; MODERATELY POROUS; BROKEN, DIFFUSE HORIZON BOUNDARY.

BM: 2 TO 17 CM, RANGE 0 TO 16 CM; MATRIX MOIST 7.5YR 4/6; SILT LOAM; WEAK TO MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MEDIUM, HORIZONTAL ROOTS; MODERATELY POROUS; WAVY, CLEAR HORIZON BOUNDARY.

2CK1: 17 TO 45 CM, RANGE 28 TO 32 CM; MATRIX MOIST 10YR 3/3; GRAVELLY SILT LOAM; WEAK, VERY FINE TO FINE, SUBANGULAR BLOCKY STRUCTURE PSEUDO; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, MEDIUM, HORIZONTAL ROOTS; MODERATELY POROUS; MODERATE EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

2CK2: 45 TO 85 CM; MATRIX MOIST 10YR 2/1; GRAVELLY LOAM; STRUCTURELESS STRUCTURE; MASSIVE SECONDARY STRUCTURE; LOOSE CONSISTENCE; VERY FEW, MEDIUM, HORIZONTAL ROOTS; MODERATELY POROUS; MODERATE EFFERVESCENCE; MODERATELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.5	42.00							
AE									
BM	6.2	2.50		20.9		18.6	1.3	0.1	0.2
2CK1	6.9		57.4						
2CK2	7.0		7.0						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2
LF				
AE				
BM	0.2		-.1	
2CK1				
2CK2				

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE														
BM										19		72	9	
2CK1										39		52	9	
2CK2	99	97	66	53						43		47	10	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE													
BM		23.1	9.4										
2CK1													
2CK2		12.6	4.9			23.0	23.0					24	87

Discussion

In terms of landform surface expression, physiographic position, and vegetation cover, SB2 resembles the Fairview 2 (FV2) Ecosite. However, in contrast to the calcareous Colluvium C of SB2, FV2 occurs on colluvial landforms comprised of noncalcareous, coarse textured colluvium (Colluvium A) and noncalcareous, medium textured colluvium (Colluvium B) and has acidic rather than neutral or alkaline soils. Also, SB2 appears similar to some tracts of IB3 but the latter occurs on landslide materials. The SB2 Ecosite is separated from other SB Ecosites primarily on vegetational differences as outlined in Table 322. Some tracts mapped as SB2A may appear similar to SB1, but can be distinguished be-

Table 326 Stand (JE8150) illustrating the Engelmann spruce-subalpine fir/false azalea (C14) v.t. of the SB2 Ecosite.

TREE LAYER	
Abies lasiocarpa	30
Picea engelmannii	10
TALL SHRUB LAYER	
Abies lasiocarpa	06
Picea engelmannii	04
SHRUB LAYER	
Abies lasiocarpa	04
Menziesia glabella	04
Picea engelmannii	02
Rhododendron albiflorum	.5
HERB-DWARF SHRUB LAYER	
Arnica cordifolia	.5
Pyrola secunda	.5
Ribes spp.	.5
Vaccinium caespitosum	.5
Vaccinium scoparium	.5
BRYOID LAYER	
Hylocomium splendens	45
Lepraria membranacea	.5
Peltigera aphthosa	03
Peltigera canina	.5
Pleurozium schreberi	05
Timmia austriaca	30
EPIPHYTES	
Bryoria pseudofuscescens	.5
Cetraria pinastri	.5
Hypogymnia enteromorpha	.5
Hypogymnia physodes	.5
Lecanora allophana	.5
Lecanora collocarpa	.5
Lecanora impudens	.5
Letharia vulpina	.5
Parmelia sulcata	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5
Platismatia glauca	.5
Usnea alpina	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

cause they have 20 to 50% of their landscape affected by snow avalanches, whereas SB1 has >50% of the landscape affected. The Wildflower 1 and 4 (WF1, WF4) Ecosites are the Upper Subalpine counterparts of SB2.

SB3 - SAWBACK 3 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, SB3, encompasses colluvial landforms comprised of calcareous, medium textured colluvium (Colluvium C). These exist as blankets overlying bedrock on steep valley walls and as aprons at major slope breaks. Orthic Eutric Brunisols and Orthic Regosols are the dominant soils. Orthic Eutric Brunisols are most abundant. Vegetation cover is dominated by the lodgepole pine/juniper/bearberry (C3), lodgepole pine/buffaloberry/showy aster (C6) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s.

Geomorphology

The SB3 Ecosite is typified by relatively stable, colluvial landforms comprised of calcareous, medium textured colluvium (Colluvium C). These exist as blankets overlying inclined bedrock and colluvial aprons at major slope breaks. Surficial veneers of altered, medium textured eolian material (Eolian material B) occur rarely on SB3 tracts. Erosional and colluvial processes appear to have removed or incorporated much of the windblown accumulations. Till occasionally underlies colluvial material along lower, more gentle slopes of SB3 tracts. Landforms comprised of thin fluvial deposits, generally calcareous, coarse, stratified fluvial material (Fluvial material B), occasionally overlie colluvium on avalanched portions of some SB3A tracts. Topographically, SB3 displays long, linear, inclined slopes commonly ranging from 45 to 90%. Slopes < 45% and > 90% may occur occasionally. Surface form is controlled by deposition and underlying bedrock. Colluvial veneers occur occasionally on SB3 but dominate on tracts mapped as SB3X. Tracts with failed slopes (mapped as SB3F), including failure of the unconsolidated material and partial failure of underlying bedrock, occur occasionally.

Soils

The soil component of the SB3 Ecosite has rapidly to well drained soils dominated by Orthic Eutric Brunisols and lesser amounts of Orthic Regosols. However, Orthic Regosols dominate a few SB3 tracts. Orthic Eutric Brunisols occupy localities where surface modification is weak but sufficient to retard or destroy eluvial (Ae) horizons. Orthic Regosols occupy localities where geomorphic activity is frequent, such as avalanche tracks. Eluviated Eutric Brunisols may occur in small amounts on stable portions. A pedon illustrating Orthic Eutric Brunisols of the SB3 Ecosite is described in Table 327 and shown in Color Plate 65. This pedon differs from modal soils by having, in the upper solum, two Bmk horizons that are unusually high in clay content. These horizons probably developed in a mixture of colluvial and fluvial or eolian deposits. This pedon was sampled on a tract of SB3 below the southern end of Ashlar Ridge in the Fiddle River valley in Jasper.

Vegetation

The SB3 Ecosite is dominated by the closely related lodgepole pine/juniper/bearberry (C3),

Table 327 Pedon (Alberta 1979 No. 25) description of an Orthic Eutric Brunisol of the SB3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: SB3.

LOCATION: MILITARY GRID REF. 11 UNJ 4700 8980; NTS MAP AREA 83F 4W.

CLIMATE: 1480 METERS ABOVE MEAN SEA LEVEL. STATION AT MIETTE HOT SPRI

VEGETATION: VPN=PA913Z*VTH=C6*.

SOIL SITE: PARENT MATERIAL 1: CLAYEY (>35% CLAY) AND UNDIFFERENTIATED, WEAKLY CALCAREOUS (1 TO 6% CACO3); PARENT MATERIAL 2: COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), COLLUVIAL, LIMESTONE; LANDFORM CLASSIFICATION: COLLUVIAL, BLANKET; SLOPE: 8% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING SOUTH, SITE AT UPPER SLOPE POSITION; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED AND WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; VERY STONY; NONROCKY.

SPECIAL NOTES: SSH=DA9143*APN=010-006*PCP=ZAG.1AC(2-3)3AG.1AC(4-5)*LFM=CB/BI*DATE=SEPT.19,1979*

LF: 4 TO 0 CM, RANGE 3 TO 6 CM; HORIZON DRY; MATRIX DRY 7.5YR 3.5/2; PLENTIFUL, VERY FINE AND FINE AND MEDIUM ROOTS; MODERATELY POROUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

BMK1: 0 TO 5 CM, RANGE 4 TO 8 CM; HORIZON DRY; MATRIX DRY 7.5YR 5/4; SILTY CLAY LOAM; WEAK TO MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; WEAK, FINE, GRANULAR SECONDARY STRUCTURE; SLIGHTLY HARD CONSISTENCE; PLENTIFUL, VERY FINE AND FINE AND MEDIUM ROOTS; MODERATELY POROUS; WEAK EFFERVESCENCE; WEAKLY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

BMK2: 5 TO 19 CM, RANGE 13 TO 16 CM; HORIZON DRY; MATRIX DRY 7.5YR 5/4; MATRIX DRY 7.5YR 5/4; SILTY CLAY LOAM; WEAK TO MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; WEAK, FINE, GRANULAR SECONDARY STRUCTURE; SLIGHTLY HARD CONSISTENCE; PLENTIFUL, VERY FINE AND FINE AND MEDIUM ROOTS; MODERATELY POROUS; WEAK EFFERVESCENCE; MODERATELY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

2CK: 19 TO 36 CM, RANGE 14 TO 20 CM; HORIZON DRY; MATRIX DRY 10YR 4.5/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; FEW, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; MODERATELY POROUS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

2CK2: 36 TO 79 CM; HORIZON DRY; MATRIX DRY 10YR 5/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SLIGHTLY HARD CONSISTENCE; VERY FEW, MICRO AND VERY FINE AND FINE ROOTS; MODERATELY POROUS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CAPB EQU.%
LF	6.2	41.00	
BMK1	6.8	2.60	1.9
BMK2	7.1	1.70	4.0
2CK	7.2		52.0
2CK2	7.5		43.5

CHEMICAL DATA (SURVEY)

	EXTRACT IRON (%)		EXTRACT ALUMINUM (%)	
HORIZON	1	2	1	2
LF				
BMK1	0.1		<.1	
BMK2	0.1		<.1	
2CK				
2CK2				

PHYSICAL DATA (SURVEY)

	% PASSING				PARTICLE SIZE ANALYSIS						% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
BMK1										9		51	40	
BMK2										9		52	39	
2CK										22		61	17	
2CK2		99	82	55	59					23		64	13	

PHYSICAL DATA

	MOISTURE STATUS (%)							ENGINEERING				
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
BMK1		32.9	16.3										
BMK2													
2CK													
2CK2		29.7	6.8			29.8	37.8					49	87

lodgepole pine/buffaloberry/showy aster (C6), and lodgepole pine/buffaloberry/twinflower (C19) v.t.s. These v.t.s reflect the extensive effects of fire in the Lower Subalpine Ecoregion in both parks. Accessory v.t.s on SB3 are lodgepole pine/buffaloberry/grouseberry (C18) and lodgepole pine/false azalea/grouseberry (C20). Minor amounts of avalanche associated v.t.s occur on tracts mapped as SB3A. A stand illustrating the C6 v.t. of SB3 is described in Table 328 and shown in Plate 157 and represents the vegetation at the pedon sample site described above in Table 327.

Table 32B Stand (PA9132) illustrating the lodgepole pine-buffaloberry/showy aster (C6) v.t. of the SB3 Ecosite.

TREE LAYER	
Pinus contorta	55
SHRUB LAYER	
Shepherdia canadensis	35
HERB-DWARF SHRUB LAYER	
Arctostaphylos uva-ursi	01
Aster ciliolatus	.5
Aster conspicuus	15
Disporum trachycarpum	05
Elymus innovatus	10
Fragaria virginiana	.5
Galium boreale	02
Juniperus communis	03
Pyrola secunda	02
Rosa acicularis	03
Spiraea lucida	02
Symphoricarpos albus	01
Vicia americana	02
BRYOID LAYER	
Cladonia spp.	.5
Dicranum fuscescens	.5
Grimmia apocarpa	.5
Hylocomium splendens	10
Hypnum revolutum	.5
Mnium spinosum	.5
Pohlia nutans	.5
Pylaisiella polyantha	.5
Ptilidium pulcherrimum	.5
EPIPHYTES	
Bryoria fuscescens	.5
Cetraria pinastri	.5
Hypogymnia austerodes	.5
Hypogymnia physodes	.5
Parmelia sulcata	.5
Parmeliopsis hyperopta	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

In terms of landform surface expression and physiographic position the SB3 Ecosite resembles the Fairview 2 (FV2) Ecosite. However, in contrast to the calcareous Colluvium C of SB3, FV2 occurs on colluvial landforms comprised of noncalcareous, coarse textured colluvium (Colluvium A) and noncalcareous, medium textured colluvium (Colluvium B) and has acidic rather than neutral or alkaline soils. The SB3 Ecosite may also appear similar to portions of Ishbel 1 (IB1), but the latter is differentiated by hummocky landslide materials.

SB4 - SAWBACK 4 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, SB4, is dominated by a landform pattern comprised of discontinuous colluvial blankets and veneers overlying inclined bedrock surfaces. The colluvial segment, consisting of calcareous, medium textured colluvium (Colluvium C), is more extensive than the exposed bedrock segment. Orthic Eutric Brunisols, Orthic Regosols and Orthic Humic Regosols characterize the soils of SB4. A mosaic of v.t.s. in which Englemann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) and white spruce/juniper/bearberry (O17) are more abundant than lodgepole pine/juniper bearberry (C3) and shrubby cinquefoil/bearberry-northern bedstraw (L1) is characteristic.

Geomorphology

The SB4 Ecosite occurs on shallow, discontinuous colluvial landforms consisting of calcareous, medium textured colluvium (Colluvium C). Exposed bedrock escarpments are subdominant. Underlying and exposed bedrock is predominantly calcareous. Geomorphic activity on SB4 primarily consists of shallow colluviation of varying intensity across the landscape. Avalanching and related processes also occur (SB4A) but are subdominant. Sheet erosion is extensive but of minor consequence, whereas locally, stream erosion in avalanched couloirs is more important to soil and vegetation development. Rubble without fine earth material for soil development is common on some SB4 tracts, particularly those occurring below steep rock walls.

Topographically, SB4 displays long, linear, inclined slopes commonly ranging from 45 to >100%. These slopes consist of discontinuous colluvial veneers and blankets broken by patches of exposed bedrock. Tracts mapped as SB4 with complex topography have linear slopes whose continuity is broken by one or more exceptionally steep bedrock escarpments and predominantly occur on southerly facing slopes. Surface form is controlled by deposition and underlying bedrock. Colluvial veneers dominate tracts mapped as SB4X.

Soils

Soil distribution and development on the SB4 Ecosite is governed by the degree and intensity of surface colluviation and, to a lesser extent, avalanching. Orthic Eutric Brunisols, Orthic Regosols, and Orthic Humic Regosols are dominant. Orthic Eutric Brunisols are most abundant. However, Orthic Regosols and Orthic Humic Regosols dominate a few SB4 tracts. Orthic Eutric Brunisols occupy localities where surface modification is weak but sufficient to retard or destroy eluvial (Ae) horizons. Orthic Regosols and Orthic Humic Regosols occupy localities where geomorphic removal or accretion is frequent and intense. Eluviated Eutric and Orthic Melanic Brunisols occur in minor

amounts. Orthic Regosols also occur on unvegetated rubbly sites and couloirs.

The rapidly to well drained soils of SB4 reflect the calcareous, medium textured parent material. Orthic Eutric Brunisols have thin sola and weakly developed Bm or Bmk horizons. Orthic Humic Regosols have thick Ah horizons which have built up by a combination of organic matter incorporation into the surface and physical accretion of surface material rich in organic matter. Orthic Regosols and Orthic Eutric Brunisols may have thin Ah horizons. Lithic soil phases are common and dominate tracts mapped as SB4X. A pedon illustrating a lithic phase of Orthic Eutric Brunisols is described in Table 329 and shown in Color Plate 66. This pedon was sampled in the Sundance Range above the confluence of Brewster and Fatigue Creeks in Banff.

Table 329 Pedon (Alberta 1978 No. 66) description of an Orthic Eutric Brunisol, lithic phase, of the SB4 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1970. SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: SB4.

LOCATION: MILITARY GRID REF. 11 UNS 9000 6940; NTS MAP AREA 82O 4E.

CLIMATE: 1940 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS POOR RELEVANCE TO THE SOIL SITE.

VEGETATION: VPH=JCB004 VTH=C3M..

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), COLLUVIAL, LIMESTONE; DEPTH TO BEDROCK IS 0.3 M; LANDFORM CLASSIFICATION: ACTIVE COLLUVIAL, VENEER; SLOPE: 70% COMPLEX SLOPE , FACING SOUTHWEST, SITE AT LOWER SLOPE POSITION, 100 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, MODERATELY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; EXCEEDINGLY STONY; EXCEEDINGLY ROCKY.

SPECIAL NOTES: SSH=NT8003+ARH=011-13+RLUP15+PCF+6AB,2AC(1-2)+AG,2AC(3-4)+MASS WASTING+NO SAMPLE OF AHK+LFH=CV/RI-MM

LF: 5 TO 0 CM, RANGE 3 TO 7 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/2; PLENTIFUL, VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AHK: 0 TO 3 CM, RANGE 0 TO 4 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/2; GRAVELLY LOAM; WEAK, VERY FINE TO FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; IRREGULAR, GRADUAL HORIZON BOUNDARY.

ABK: 3 TO 9 CM, RANGE 4 TO 7 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 3/4; GRAVELLY SILT LOAM; WEAK, VERY FINE TO FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; WAVY, GRADUAL HORIZON BOUNDARY.

BMK: 9 TO 31 CM, RANGE 20 TO 24 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6; GRAVELLY SILT LOAM; VERY WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; MODERATELY CALCAREOUS; IRREGULAR, ABRUPT HORIZON BOUNDARY.

R: 31 CM

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LF	6.6	36.00	12.9
AHK			
ABK	7.1	4.30	33.5
BMK	7.3	4.00	34.6
R			

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AHK				
ABK				
BMK	0.1		0.1	
R				

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS													
	% PASSING										% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AHK														
ABK										29	62		9	
BMK		99	88	69	48					25	67		6	
R														

PHYSICAL DATA

	MOISTURE STATUS (%)						ENGINEERING						
HORIZON	0.1 ATM	0.33 ATM	15 ATM	OVEN. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AHK													
ABK												24	83
BMK			16.6	14.5									
R													

Vegetation

The SB4 Ecosite is dominated by the Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) and white spruce/juniper/bearberry (O17) v.t.s. The lodgepole pine/juniper/bearberry (C3) and shrubby cinquefoil/bearberry-northern bedstraw (L1) v.t.s are subdominant. These v.t.s are commonly found on southerly exposures with subxeric moisture regimes. The v.t.s reflect exposed bedrock surfaces and unstable soils. Unvegetated portions on SB4 tracts occur with exposed bedrock and very active colluviation. Tracts modified by snow avalanching are designated as SB4A. The aspen/hairy wild rye-showy aster (C22) is an accessory v.t. common to these SB4A tracts. Minor amounts of other v.t.s associated with avalanched environments of SB4 are Engelmann spruce-subalpine fir/rock willow/alpine bearberry (O12), juniper-willow (L2), willow-dwarf birch-shrubby cinquefoil (S10) and hairy wild rye-junegrass-bearberry (H14). Also occurring in minor amounts on more stable portions are the lodgepole pine/buffaloberry/showy aster (C6) and lodgepole pine/buffaloberry/twinflower (C19) v.t.s. A stand illustrating an open variant of the C3 v.t. is described in Table 330 and shown in Plate 158 and represents the vegetation at the pedon sampling site described above in Table 329.

Discussion

The SB4 Ecosite is separated from other SB Ecosites primarily on the basis of vegetational and landform differences as outlined in Table 322. The Wildflower 3 (WF3) Ecosite is the Upper Subalpine counterpart to SB4.

Table 330 Stand (JC8004) illustrating an open variant of the lodgepole pine/juniper/bearberry (C3) v.t. of the SB4 Ecosite.

TREE LAYER	
Pinus contorta	05
TALL SHRUB LAYER	
Pinus contorta	01
SHRUB LAYER	
Pinus contorta	.5
Populus tremuloides	02
HERB-DWARF SHRUB LAYER	
Achillea millefolium	.5
Anemone multifida	.5
Anemone patens	.5
Arctostaphylos uva-ursi	09
Carex concinna	.5
Cerastium arvense	.5
Draba spp.	.5
Elymus innovatus	01
Fragaria virginiana	.5
Juniperus communis	02
Linnaea borealis	01
Lonicera involucrata	.5
Picea engelmannii	.5
Potentilla fruticosa	01
Rosa acicularis	02
Shepherdia canadensis	.5
Solidago decumbens	.5
Zygadenus elegans	.5
BRYOID LAYER	
Bryum spp.	.5
Grimmia spp.	.5
Hulia nigrocruenta	.5
Lecidea spp.	.5
Leptogium saturninum	.5
Psora rubiformis	.5
Solorina bispora	.5
Toninia coeruleonigricans	.5
Tortella fragilis	.5
Verrucaria virens	.5
Xanthoria elegans	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

SB5 - SAWBACK 5 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, SB5, encompasses blankets and veneers comprised of calcareous, medium textured colluvium (Colluvium C) overlying inclined bedrock on steep valley walls. Soils of the SB5 Ecosite reflect varying amounts of humus accumulation and degrees of surface modification by erosion or accretion. Orthic Eutric Brunisols, Orthic Melanic Brunisols, and Orthic Humic Regosols typify the soil component. Vegetation is dominated by the hairy wild rye-junegrass-bearberry (H14) v.t.

The SB5 Ecosite occurs on southerly aspects exclusively in the Front Ranges of Banff and Jasper. Fig. 52 for the Snowflake 1 (SF1) Ecosite shows the SB5 Ecosite on the landscape.

Geomorphology

The SB5 Ecosite encompasses colluvial blankets and veneers comprised of calcareous, medium textured colluvium (Colluvium C) overlying inclined bedrock on steep valley walls. Underlying bedrock is predominantly calcareous Mesozoic strata. Geomorphic activity on SB5 is primarily soil creep. Till occasionally underlies colluvial material along lower gentler slopes.

Topographically, SB5 displays long, linear, inclined slopes commonly ranging from 45 to 90%. Surface form is controlled by deposition and underlying bedrock. Tracts with failed slopes (mapped as SB5F), including failure of unconsolidated material and partial failure of underlying bedrock, occur occasionally.

Table 331 Pedon (Alberta 1979 No. 88) description of an Orthic Eutric Brunisol of the SB5 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: SB5.

LOCATION: MILITARY GRID REF. 11 UNE 9620 9310; NTS MAP AREA 820 SE.

CLIMATE: 1950 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 9 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: GRASSES AND FORBES, MATURE. VPN=JD9979=VTN=H14=.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), COLLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: ACTIVE COLLUVIAL, VENEER; SLOPE: 65% SLOPE OF CLASS 8 (46-70%), FACING SOUTHWEST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,500 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, VERY RAPID SURFACE RUNOFF, SEEPAGE ABSENT; VERY STONY; SLIGHTLY ROCKY.

SPECIAL NOTES: SSN=WT9147=APN=010-169=RLU=15=PCF=ZAG,1AC(2,5)3AB,3AC(3,4,6)4AG,3AC(7)8AB,4AC(8)=LFH=CV/RI=TURFY AH=BM1=CHARCOAL IN AHB=SOME COARSE FRAGMENTS IN LF FROM ACTIVE COLLUVIATION=DATE=AUG.27,1979=

LF: 3 TO 0 CM, RANGE 2 TO 4 CM; MATRIX MOIST 10YR 2/1; MODERATE EFFERVESCENCE; WAVY, CLEAR HORIZON BOUNDARY.

AH: 0 TO 8 CM, RANGE 6 TO 10 CM; MATRIX MOIST 10YR 3/1; SILT LOAM; WEAK, VERY FINE, GRANULAR STRUCTURE; SOFT CONSISTENCE; ABUNDANT, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BM1: 8 TO 16 CM, RANGE 5 TO 9 CM; MATRIX MOIST 7.5YR 3/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, GRADUAL HORIZON BOUNDARY.

BM2: 16 TO 27 CM, RANGE 9 TO 14 CM; MATRIX MOIST 7.5YR 3/3; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AHB: 27 TO 34 CM, RANGE 3 TO 7 CM; MATRIX MOIST 10YR 3/1.5; SILT LOAM; WEAK, VERY FINE, GRANULAR STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BMB1: 34 TO 47 CM, RANGE 10 TO 16 CM; MATRIX MOIST 5YR 4/4; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE ROOTS; WAVY, GRADUAL HORIZON BOUNDARY.

BMB2: 47 TO 68 CM, RANGE 19 TO 25 CM; MATRIX MOIST 7.5YR 4/4; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

CK: 68 TO 115 CM; MATRIX MOIST 10YR 4/2; GRAVELLY COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE ROOTS; WEAK EFFERVESCENCE; STRONGLY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	6.6	30.90		58.3		39.5	8.1	-.1	1.3
AH	6.3	14.59		26.0		19.8	5.0	0.1	0.4
BM1	6.3	6.10		17.8		15.3	3.6	0.2	0.2
BM2	6.4	3.10		47.7		36.6	9.6	0.2	0.2
AHB	6.4	10.10		9.2		7.2	1.7	0.1	0.2
BMB1	6.7	1.50	0.6	9.2		7.8	2.3	0.1	0.1
BMB2	6.7	1.00	1.9						
CK	7.5		19.8						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AH				
BM1	0.2		0.1	
BM2	0.2		0.1	
AHB				
BMB1	0.1		-.1	
BMB2	0.1		0.0	
CK				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 78-2U SILT	% OF SAMPLE 50-2U SILT	% OF SAMPLE 2U CLAY	% OF SAMPLE 0.2U CLAY
LF														
AH					2	1	1	5	10	19		64	17	
BM1					2	3	2	8	16	31		60	9	
BM2					2	2	2	5	14	25		66	9	
AHB					1	2	2	7	14	24		68	8	
BMB1					0	9	4	7	16	44		54	2	
BMB2					3	3	2	6	18	32		60	8	
CK	99	79	56	47	16	12	6	7	10	51		44	5	

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AH								
BM1								
BM2								
AHB								
BMB1								
BMB2								
CK	20.0	36.0		19.0	1.7		1E	1B

Soils

Soil distribution and development on the SB5 Ecosite reflect varying amounts of humus accumulation and degrees of surface modification by soil creep. Orthic Eutric Brunisols, Orthic Melanic Brunisols, and Orthic Humic Regosols are the dominant soils. Orthic Eutric Brunisols are associated with moderately eroded localities where removal is or has been more important than accretion. Orthic Melanic Brunisols and Orthic Humic Regosols occur on more severely affected localities where accretion is relatively important.

The rapidly to well drained soils of SB5 reflect the calcareous, medium textured parent material. Orthic Eutric Brunisols have thin sola and weakly developed Bm or Bmk horizons. Orthic Melanic Brunisols and Orthic Humic Regosols have thick Ah or Ahk horizons physically built up by the accumulation of organo-mineral erosional products. Orthic Regosols are accessory soils generally associated with sites where removal is more important than accretion. Eluviated Eutric Brunisols occur in minor amounts in localities where forest cover is well established. Orthic Regosols and Orthic Eutric Brunisols may have thin Ah horizons. A pedon illustrating Orthic Eutric Brunisols of SB5 is described in Table 331 and shown in Color Plate 67. This pedon, sampled in the Cascade River valley in Banff, has an Ahb horizon indicative of recent soil instability.

Vegetation

The SB5 Ecosite is dominated by the hairy wild rye-junegrass-bearberry (H14) v.t. The accessory v.t. hairy wild rye-wild strawberry-fireweed (H5) and minor amounts of other grassland v.t.s occur. The root mats of these grassland v.t.s are responsible for stabilizing these colluvial slopes and preventing erosion. Where small areas of established forest stands are included in the tracts mapped as SB5, the accessory v.t. Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) usually occurs. Small amounts of the lodgepole pine/buffaloberry/showy aster (C6) and Douglas fir/hairy wild rye (C1) v.t.s occur on tracts of SB5F between Johnston Creek and Hillsdale in Banff. Unvegetated landscape segments occur on very steep eroded gullies and slopes where soil is unstable. A vegetation plot illustrating the H14 v.t. is described in Table 332 and shown in Plate 159 and represents vegetation at the pedon sample site described above in Table 331.

Discussion

The SB5 Ecosite is separated from other SB Ecosites primarily on vegetational differences as outlined in Table 322. The SB5 Ecosite

Table 332 Stand (JD9079) illustrating the hairy wild rye-junegrass-bearberry (H14) v.t. of the SB5 Ecosite.

	HERB-DWARF SHRUB LAYER
Achillea millefolium	02
Agrostis spp.	.5
Antennaria rosea	.5
Arctostaphylos uva-ursi	.5
Arenaria obtusiloba	.5
Bromus pumpellianus	20
Campanula rotundifolia	.5
Carex atrosquama	.5
Carex phaeocephala	.5
Cerastium arvense	.5
Delphinium glaucum	.5
Draba incerta	.5
Elymus innovatus	25
Epilobium angustifolium	.5
Fragaria virginiana	01
Gentiana propinqua	.5
Hedysarum sulphurescens	15
Koeleria cristata	25
Oxytropis splendens	.5
Penstemon procerus	.5
Poa arctica	.5
Poa fendleriana	10
Potentilla nivea	.5
Rhinanthus crista-galli	.5
Rosa acicularis	01
	BRYOID LAYER
Bryum algovicum	.5
Bryum pseudotriquetrum	.5
Cetraria cucullata	.5
Cetraria ericetorum	.5
Cetraria islandica	.5
Drepanocladus uncinatus	.5
Peltigera rufescens	.5
Thamnolia subuliformis	.5
Tortula spp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

may appear similar to segments of Goat 2 (GT2) tracts occurring on exposed slopes, but the latter occurs on calcareous, medium textured till (Till C) rather than Colluvium C. Occasionally, Tyrrell 2 (TR2) may also appear similar to SB5 but can be distinguished by the vegetational differences associated with the Upper Subalpine in the former and the Lower Subalpine in the latter. The Wildflower 7 (WF7) Ecosite is the Upper Subalpine counterpart of SB5.

SF - SNOWFLAKE ECOSECTION

The SF Ecosection occurs on medium textured till of variable calcareousness in the Upper Subalpine portion of the Subalpine Ecoregion. Cryosolic soils dominate, but occur in a landscape pattern with less extensive gleyed Brunisolic soils. Both are found with moist Engelmann spruce-subalpine fir forest v.t.s.

The SF Ecosection is prevalent on northerly aspects in the Front Ranges of Banff and Jasper, from Banff townsite northwestward. Numerous extensive areas are mapped, such as on the valley walls above Rock and Mowitch Creeks in northern Jasper.

Table 333 General features of the Snowflake 1 (SF1) Ecosite.

Ecosite	Landform	Soils	Vegetation
SF1	Till B,C; blanket	Static Cryosol > gleyed Eutric Brunisol	Engelmann spruce-subalpine fir forest

Only one Ecosite (SF1) is recognized within the SF Ecosection, as outlined in Table 333. The SF Ecosection is shown in a hypothetical landscape context in Fig. 52.

SF1 - SNOWFLAKE 1 ECOSITE

Ecosite Concept

The SF1 Ecosite occurs on blankets of calcareous, medium textured till (Till C), occasionally noncalcareous, medium textured till (Till B), over inclined bedrock in the Upper Subalpine portion of the Subalpine Ecoregion. Surface modification by solifluction is common and has affected the genesis of the dominant Regosolic Static Cryosol soils, while Orthic Static Cryosols have developed on more stable areas. Gleyed Eutric Brunisols occupy margins and patches on tracts where soils lack permafrost, but are ice-free only briefly in late summer. Vegetation is most commonly Engelmann spruce-subalpine fir/rock willow/white mountain heather (C24), but some tracts are predominantly Engelmann spruce-subalpine fir/feathermoss (C13).

The SF1 Ecosite is restricted to northerly aspects almost exclusively in the Front Ranges, and underlain by material derived largely from Mesozoic strata. Plate 160 shows SF1 in a typical landscape setting (topography, bedrock structure and lithology, aspect). Tracts are mapped from the Glacier Pass area on Jasper's northern boundary to their most southerly extent in the parks on the flank of Mount Brewster near Banff townsite.

Geomorphology

The SF1 Ecosite occurs on blankets of calcareous, medium textured till (Till C) over inclined bedrock, with surfaces often modified by solifluction. The till is a phase of Till C largely derived from Mesozoic strata, and as such, is often dark (low chroma and value) in color and may be lower in lime than modal. Less frequently, tracts are mapped on noncalcareous, medium textured till (Till B) where genetic material is derived from Jurassic or Lower Cretaceous (Fernie Group, Kootenay, Nikanassin, and Luscar Formations) rock.

Solifluction is a common surface modifier, with the active layer above the permafrost often corresponding directly to the depth affected. A strongly mounded microtopography is typical of the inclined slopes with superimposed solifluction lobes. Simple slopes between 30 to 70% are dominant, but several tracts with inclined complex slopes between 30 and 45% exist. The latter include failed tracts and northerly slopes fringing rolling plateaus such as the one separating the Panther and Dormer Rivers in Banff. Snow avalanching affects very few tracts because Mesozoic strata are not cliff-forming and upper slopes are seldom steep enough to be avalanche starting zones. Also, north of Banff townsite the Front Ranges are some distance east of the Continental Divide, and snowfall is less than areas to the west (Janz and Storr 1977) where avalanching is more common. Veneers of Eolian material B are sporadically present on the most stable sites, but this deposit is often completely mixed with other soliflucted material.

Several tracts are mapped as SF1F (failed). In most cases the process is inactive, but in some instances it may be slowly active. Solifluction lobes have apparently failed in some instances, leaving unvegetated scars.

Soils

Dominant soils of SF1 are Cryosolic in that they are frozen to within 1 m of the surface throughout the year. Regosolic Static Cryosols are most abundant, and their genesis is modified by solifluction. This process disrupts horizon development, and produces turbic phases where the usually thick surface organic layer is mixed into underlying mineral materials. Table 334 describes a sampled pedon, located on the slope shown in Plate 160, northeast of Mount Sassenach in Jasper. It illustrates a Regosolic Static Cryosol, turbic phase, of SF1. Color Plate 68 shows this pedon.

Orthic Static Cryosols may be prevalent on stable sites in the absence of solifluction or where its influence is weakly expressed, such as between lobes. When undisturbed altered, medium textured eolian material (Eolian material B) is present, thicker B horizons may develop, producing Brunisolic Static Cryosols.

Margins and patches within tracts may lack permafrost, but are usually only free of frost briefly in late summer. Gleyed Eutric Brunisols are most common in this instance, but

Figure 52 Landscape schematic showing the relationship of the Snowflake I (SF1) Ecosite to other Ecosites.

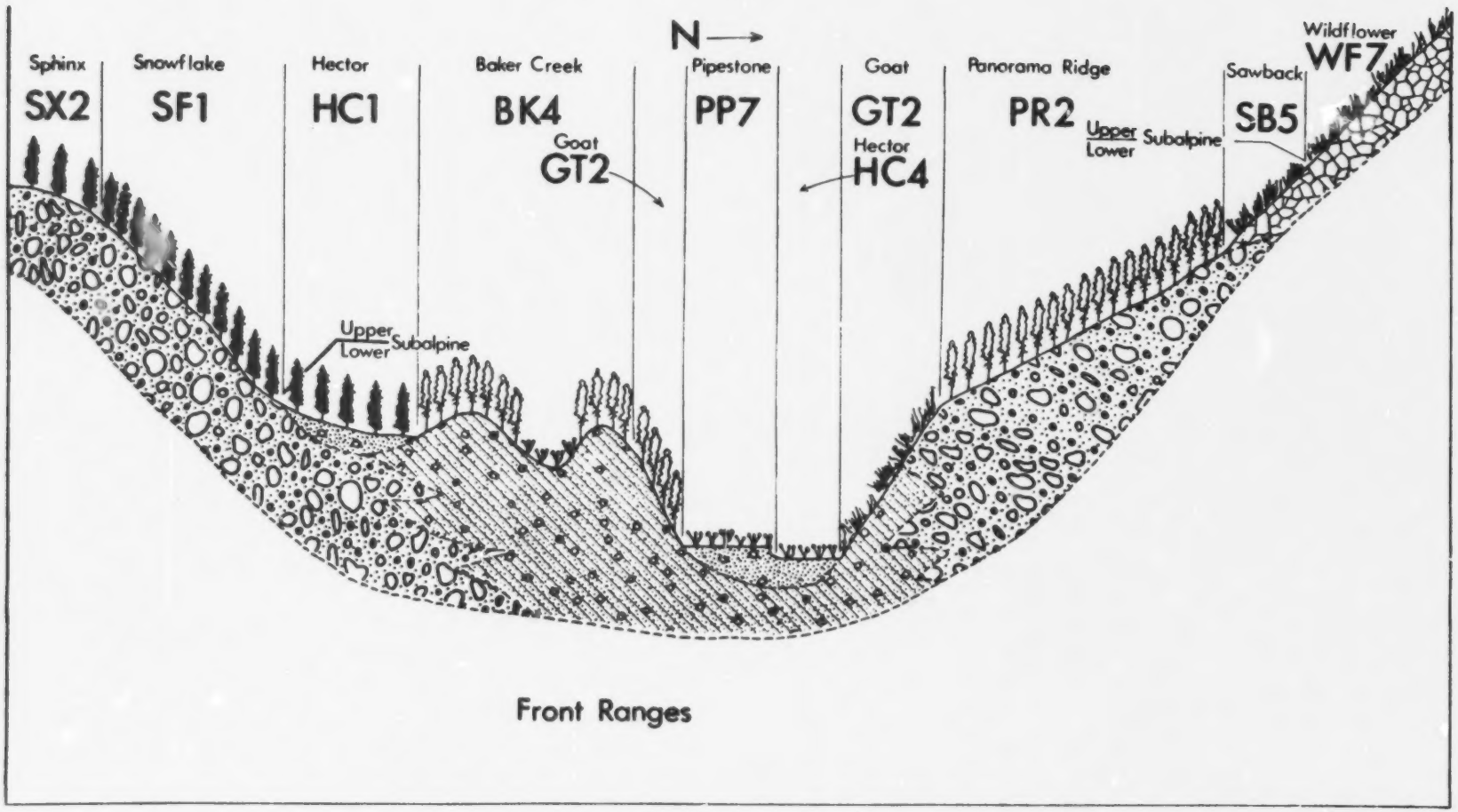


Table 334 Pedon (Alberta 1979 No. 66) description of a Regosolic Static Cryosol, turbic phase, of the SF1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: REGOSOLIC STATIC CRYOSOL. SOIL MAP UNIT: NOTATION: S/1.

LOCATION: MILITARY GRID REF. 11 UNK 880 320; NTS MAP AREA 83E 8W.

CLIMATE: 2020 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 0 DEG(C) AT 50 CM IN SEPTEMBER, NO. 2 WAS -1 DEG(C) AT 80 CM IN SEPTEMBER.

VEGETATION: VPN=PA9134*VTH=C24*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), MORAINAL (TILL), SEDIMENTARY; LANDFORM CLASSIFICATION: ACTIVE MORAINAL, SOLIFLUCTED, INCLINED; SLOPE: 55% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING NORTH, SITE AT MIDDLE POSITION, STRONGLY MOUNDED MICROTOPOGRAPHY,400 M LONG; SOIL MOISTURE AND DRAINAGE: MODERATELY WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY; PERMAFROST: 0.4 M TO LAYER, ACTIVE LAYER IS 0.4 M THICK, 20 % ICE IN CONTROL SECTION, WELL BONDED AND EXCESS ICE AND ICE VISIBLE AND ICE LESS THAN 2.5 CM THICK AND INDIVIDUAL ICE CRYSTALS OR INCLUSIONS AND RANDOM OR IRREGULAR CRIENTED ICE.

SPECIAL NOTES: SSN=MT9160*APN=015-155*RLU=15*PCF=2GR,1CB(2),2GR,2AG,2CB(3,5)1GR(4-6)3GR,1AG,2CB,1AC(7)*LFH=MI-8*DATE=SEPT.21, 1979*TURBICPHASE*

LFH: 24 TO 0 CM, RANGE 22 TO 26 CM; HORIZON MOIST; MATRIX MOIST 5YR 3/3, MATRIX MOIST 10YR 2/1; PLENTIFUL, FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AHK: 0 TO 8 CM, RANGE 7 TO 9 CM; HORIZON MOIST; MATRIX MOIST 10YR 2.5/1; SILT LOAM; VERY WEAK, FINE, GRANULAR AND MASSIVE STRUCTURE; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; STRONGLY CALCAREOUS; 10% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

CK1: 8 TO 20 CM, RANGE 9 TO 28 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/1.5; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE ROOTS; WEAK EFFERVESCENCE; VERY STRONGLY CALCAREOUS; 20% GRAVELLY AND ANGULAR GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

H+CKU1: 20 TO 25 CM, RANGE 0 TO 7 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/1; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, FINE ROOTS; MODERATELY CALCAREOUS; GRAVELLY AND COBBLY COARSE FRAGMENTS; BROKEN, CLEAR HORIZON BOUNDARY.

CK2: 25 TO 34 CM, RANGE 0 TO 13 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/1.5; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, FINE ROOTS; WEAK EFFERVESCENCE; VERY STRONGLY CALCAREOUS; 20% GRAVELLY AND ANGULAR GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

H+CKU2: 34 TO 40 CM, RANGE 5 TO 13 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/1; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, FINE ROOTS; MODERATELY CALCAREOUS; 20% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CKZ: 40 TO 85 CM; HORIZON MOIST AND WET; 10YR 3.5/1; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; STICKY CONSISTENCE; MODERATE EFFERVESCENCE; 30% GRAVELLY AND ANGULAR GRAVELLY AND COBBLY AND ANGULAR COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LFH	6.2	31.40	
AHK	7.1	9.80	19.5
CK1	7.3	3.10	34.7
H+CKU1	7.2	27.50	7.4
CK2	7.4	1.70	36.4
H+CKU2	7.2	19.00	14.5
CKZ	7.3	2.20	34.9

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LFH								
AHK								
CK1								
H+CKU1								
CK2								
H+CKU2								
CKZ	24.0	30.0					24	07

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS % PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LFH															
AHK										22		63	15		
CK1										26		63	11		
H+CKU1										34		57	9		
CK2										34		57	9		
H+CKU2															
CKZ	99	77	52	42						28		62	10		1.90

solifluction above the thawing frost in early to mid-summer may produce Gleyed Cumulic Regosols. Except for the lack of a continuously frozen layer, the morphology of these soils is similar to the Cryosolic soils.

Soils on SF1 are imperfectly drained. A saturated zone is maintained at the frozen-nonfrozen interface during the period of thaw, producing gley features that are usually indistinct because of the inherently dark colored genetic material. This melt usually seeps downslope over the frozen layer and surfaces at breaks in slope, causing wet soils and vegetation below many SF1 tracts.

Achuff and Coen (1980) present data from a Brunisolic Static Cryosol site on Mount White in Banff. They recorded a mean annual air temperature of -1.9°C, a mean annual permafrost temperature of -1.5°C at 100 cm depth (2 years data), and postulate that shallow snow depth pattern throughout the year is particularly influential to the presence of permafrost. The concordance of permafrost with materials largely derived from Mesozoic strata suggests that some quality of the genetic materials may also be instrumental in controlling the presence of permafrost.

Vegetation

The Engelmann spruce-subalpine fir/rock willow/white mountain heather (C24) v.t. dominates SF1, although on some tracts it is subdominant to Engelmann spruce-subalpine fir/feathermoss (C13). Table 335 presents a plot from the slope shown in Plate 160. It was sampled at the pedon site (Table 334) and illustrates the C24 v.t. on SF1. Plate 26 shows this plot area.

Other v.t.s commonly occurring at higher elevations on SF1 include Engelmann spruce-subalpine fir/heather/feathermoss (C34) and Engelmann spruce-subalpine fir/heather (O10). On slopes that drop from rolling plateaus, Engelmann spruce-subalpine fir/rock willow/alpine bearberry (O12), Engelmann spruce-subalpine fir/valerian-fleabane (O9) and, less frequently, Engelmann spruce-subalpine fir/mountain avens (O19) fringe the upper boundary.

Forests on SF1 are invariably successionally mature. Solifluction frequently causes trees to lean, creating a drunken forest appearance. A marked change in the appearance of forests from a distance often occurs near the upper boundary of tracts (Plate 160). This linear break is inferred to be the margin of the underlying permafrost.

Discussion

Though dominantly a Front Ranges Ecosite, a few SF1 tracts are mapped in the Main Ranges, notably in Dolomite and Martin Creek valleys in Banff. Main Range tracts have many characteristics of SF1, but the presence of Cryosolic soils on them has not been documented.

Aspect affects the distribution and extent of SF1 to a greater extent than it does most other Ecosites. On northerly slopes the boundary between Upper and Lower Subalpine is significantly depressed, since forested, Cryosolic sites are considered as Upper Subalpine. In the Rock Creek area in Jasper, SF1 and thus Upper Subalpine is mapped as low as 1700 m. Cryosols and related vegetation occur locally on the Lower Subalpine Goat 2 (GT2) tract adjoining this creek. The SF1 Ecosite is often found in intimate association with grasslands on opposite, southerly aspects. The Upper-Lower Subalpine boundary on these southerly aspects is considerably higher than on opposite aspects. An example (Plate 161) from the Panther River valley in Banff illustrates the influence of aspect on SF1 and associated Ecosites.

Table 335 Stand (PA9134) illustrating the Engelmann spruce-subalpine fir/rock willow/white mountain heather (C24) v.t. of the SF1 Ecosite.

TREE LAYER	
Abies lasiocarpa	.5
Picea engelmannii	20
TALL SHRUB LAYER	
Abies lasiocarpa	05
Picea engelmannii	.5
SHRUB LAYER	
Abies lasiocarpa	.5
Salix glauca	05
Salix vestita	20
HERB-DWARF SHRUB LAYER	
Cassiope tetragona	20
Pedicularis bracteosa	.5
Pyrola secunda	.5
Saxifraga lyallii	.5
Equisetum scirpoides	10
BRYOID LAYER	
Campylium stellatum	.5
Cladonia arbuscula	05
Cladonia cenotea	.5
Cladonia coccifera	.5
Cladonia coniocraea	.5
Cladonia ecmocyna	04
Cladonia gonecha	.5
Cladonia pyxidata	01
Dactylina berengia	.5
Dicranum brevifolium	.5
Drepanocladus uncinatus	10
Hylocomium splendens	40
Meesia uliginosa	.5
Nephroma expallidum	.5
Peltigera aphthosa	10
Peltigera canina	.5
Pleurozium schreberi	20
Pohlia cruda	.5
Psoroma hypnorum	.5
Anastrophyllum minutum	.5
Barbilophozia lycopodioides	05
Blepharostoma tricophyllum	.5
Lophozia floerkii	.5
EPIPHYTES	
Bryoria lanestris	.5
Letharia vulpina	.5
Parmelia sulcata	.5
Usnea alpina	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Fire has had a significant effect on some SF1 tracts. In Snow Creek Pass and Tyrrell Creek valley in Banff, tracts mapped as Tyrrell 1 (TR1) and presently dominated by shrub thicket have soils with evidence of former SF1 characteristics. With forest encroachment, permafrost will probably again be established. However, permafrost does not appear to have been influenced in soils on a site near Mt. White in Banff which was burned about 50 years ago, and today has only a very open stand of trees <3 m tall.

Cryosolic soils and the dominance of the C24 and C13 v.t.s on SF1 distinguish it from Peyto Lake 1 (PL1) and Egypt 1 (EG1) that also occur on Till C and Till B respectively. The SF1 Ecosite is also more restricted in aspect and, with few exceptions, occurs in the Front Ranges only. Sphinx 2 (SX2), found on poorly drained till sites, may adjoin SF1, but lacks permafrost. Bryant 2 (BY2) occurs in the Lower Subalpine, but where forested with C13 on north aspects it closely resembles SF1. It lacks the Cryosolic soils of SF1.

SP - SPRAY ECOSECTION

The Spray (SP) Ecosection is typified by blankets and veneers of calcareous, fine textured glaciolacustrine material overlying hummocky and undulating slopes of calcareous glacial materials. The SP Ecosection is dominated by Luvisolic and Brunisolic soils and moist lodgepole pine forests.

The SP Ecosection occurs in the Lower Subalpine portion of the Subalpine Ecoregion in both Banff and Jasper. It occupies valley floor and lower slope positions in the Pipestone, Spray, and lower Cascade River valleys and the Johnston Creek valley in Banff. In Jasper it occurs in the Snaring and Rocky River valleys.

The SP Ecosection is represented by only one Ecosite (SP1). General features of the SP1 Ecosite are outlined in Table 336. Fig. 44 shows the position of SP1 on the landscape.

SP1 - SPRAY 1 ECOSITE

Ecosite Concept

The SP1 Ecosite is typified by blankets and veneers of calcareous, fine textured glaciolacustrine material overlying undulating and hummocky slopes of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) and occasionally the calcareous, medium textured Till C. The SP1 Ecosite is dominated by well to moderately well drained Orthic and Brunisolic Gray Luvisols and Eluviated Eutric Brunisols associated with the lodgepole pine/buffaloberry/grouseberry (C18) and logdepole pine/Labrador tea (C29) v t.s.

Geomorphology

The SP1 Ecosite is typified by blankets and veneers of calcareous, fine textured glaciolacustrine material overlying hummocky and undulating slopes of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). In some tracts, calcareous, medium textured till (Till C) underlies the glaciolacustrine material. Terraces consisting of Glaciolacustrine material overlying calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) occur locally on some tracts. Occasionally, ridged surfaces occur. Discontinuous, thin surficial veneers of altered, medium textured eolian material (Eolian material B) also occur. Slopes are generally complex and commonly range from 2 to 15%, although steeper slopes occur occasionally.

Soils

Well to moderately well drained Orthic and Brunisolic Gray Luvisols and Eluviated Eutric Brunisols are the dominant soils on SP1. These soils have textural B horizons, many with sufficient pedogenic clay film development to be Bt horizons, occurring at or just below the upper boundary of the glaciolacustrine material. Within the parks, Bt horizons are best expressed in glaciolacustrine deposits. Iron, aluminum, and humus enriched Bm horizons developed in Eolian material B veneers often overlie the textural B horizons. Orthic Gray Luvisols occur where the veneer is thin or absent. Orthic Eutric Brunisols occur as small areas where eluvial (Ae) horizons are weakly expressed or absent. A pedon description in Table 337 illustrates an Orthic Gray Luvisol sampled on a tract of SP1 in the Spray River valley opposite the Goat Creek confluence. Color Plate 69 shows the pedon.

Vegetation

A variety of lodgepole pine and Engelmann spruce-subalpine fir v.t.s occur on SP1. They are best represented by the lodgepole pine/

Table 336 General features of the Spray 1 (SP1) Ecosite.

Ecosite	Landform	Soils	Vegetation
SP1	Glaciolacustrine material; blanket, veneer	Gray Luvisol, Eutric Brunisol	lodgepole pine forest

Table 337 Pedon (Alberta 1976 No. 94) description of an Orthic Gray Luvisol of the SP1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC GRAY LUVISOL. SOIL MAP UNIT: NOTATION: SP1.

LOCATION: MILITARY GRID REF. 11 UPG 6042 6103; NTS MAP AREA 82O 4E.

CLIMATE: 1540 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS MODERATE RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 3 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VPN=PA7191=VTH=C9=.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), GLACIOLACUSTRINE; LANDFORM CLASSIFICATION: UNDULATING; SLOPE: 4% COMPLEX SLOPE OF CLASS 3 (2-5%), FACING LEVEL, SITE AT UPPER SLOPE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,30 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, SLOW SURFACE RUNOFF, SEEPAGE ABSENT; NONSTONY; NONROCKY.

SPECIAL NOTES: SSN=GC6102=APN=011-012=RLU=15=MANY(30 PERCENT BY VOLUME)WHITE+ FEW YELLOW MYCELIA IN LF=BT FINER THAN BCK=NO INPED PORES ID PORES IN CK3;WATER TRANSPORT ALONG CRACKS BETWEEN CLODS=LFM=LGU=THIN EOLIAN VENEER AT SURFACE=

LF: 0 TO 0 CM, RANGE 6 TO 12 CM; MATRIX MOIST 5YR 3/2; MATERIAL COMPOSITION MODERATE DECOMPOSITION; PLENTIFUL, MEDIUM AND COARSE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 2 CM, RANGE 1 TO 5 CM; MATRIX MOIST 7.5YR 6/2; SILT LOAM; WEAK, VERY FINE TO FINE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE ROOTS; FEW, VERY FINE, VERTICAL PORES; WAVY, ABRUPT HORIZON BOUNDARY.

BM: 2 TO 6 CM, RANGE 0 TO 6 CM; MATRIX MOIST 7.5YR 5/4, MATRIX MOIST 7.5YR 5/6; SILT LOAM; WEAK, FINE, PLATY STRUCTURE; WEAK, VERY FINE, SUBANGULAR BLOCKY SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE ROOTS; FEW, FINE, VERTICAL PORES; BROKEN, ABRUPT HORIZON BOUNDARY.

BT: 6 TO 15 CM, RANGE 7 TO 12 CM; MATRIX MOIST 10YR 5/4; CLAY; MODERATE TO STRONG, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; COMMON, VERY FINE, RANDOM PORES; MANY, THIN CLAY FILMS ON PED FACES-UNSPECIFIED; WAVY, ABRUPT HORIZON BOUNDARY.

BCK: 15 TO 22 CM, RANGE 6 TO 8 CM; MATRIX MOIST 10YR 5/3; SILTY CLAY; MODERATE TO STRONG, VERY FINE, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; ABUNDANT, FINE AND MEDIUM ROOTS; COMMON, VERY FINE, RANDOM, INPED, INTERSTITIAL AND TUBULAR PORES; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CK1: 22 TO 40 CM, RANGE 15 TO 20 CM; MATRIX MOIST 10YR 5/2; SILTY CLAY; STRONG, FINE, SUBANGULAR BLOCKY STRUCTURE PSEUDO; FIRM CONSISTENCE; FEW, FINE AND COARSE ROOTS; COMMON, VERY FINE, RANDOM, INPED, INTERSTITIAL AND TUBULAR PORES; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CK2: 40 TO 100 CM, RANGE 55 TO 65 CM; MATRIX MOIST 10YR 5/2; SILTY CLAY; STRONG, MEDIUM, SUBANGULAR BLOCKY STRUCTURE PSEUDO; FIRM CONSISTENCE; FEW, FINE AND COARSE ROOTS; FEW, VERY FINE, RANDOM, INPED, INTERSTITIAL AND TUBULAR PORES; EXTREMELY CALCAREOUS; WAVY, DIFFUSE HORIZON BOUNDARY.

CK3: 100 TO 120 CM; MATRIX MOIST 2.5YR 6/2; SILTY CLAY LOAM; STRONG, MEDIUM, ANSULAR BLOCKY STRUCTURE PSEUDO; VERY FIRM CONSISTENCE; VERY FEW ROOTS; INTERSTITIAL PORES; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	6.7	41.20	1.5						
AE	4.3	2.10		14.4		4.6	1.2	0.1	0.6
BM	5.1	2.40		25.3		8.0	1.8	0.1	1.4
BT	6.1	1.30		20.0		20.7	4.0	0.1	0.7
BCK	7.0		43.4						
CK1	7.2		47.6						
CK2	7.3		49.5						
CK3	7.4		57.5						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2
LF				
AE				
BM	0.2		0.1	
BT				
BCK	-.1		0.0	
CK1				
CK2				
CK3				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE														
BM										14		68	18	3
BT										11		62	27	7
BCK										3		37	60	19
CK1										3		52	45	9
CK2										3		49	48	9
CK3										1		32	47	9
										0		65	35	6

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AE								
BM								
BT								
BCK								
CK3	8.0	27.0		8.0	2.1			
CK4								
CK3	11.0	26.0		10.0	2.0			

buffaloberry/grouseberry (C18) and lodgepole pine/Labrador tea (C29) v.t.s. Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) and Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) are accessory v.t.s occurring on tracts of SP1 in Banff. Minor amounts of the lodgepole pine/dwarf bilberry (C9) v.t. occur on tracts of SP1 in the Spray River valley in Banff and small areas of the lodgepole pine/buffaloberry/showy aster (C6) v.t. occur on a tract of SP1 in the Snaring River valley in Jasper. The plot described in Table 338 illustrates the C29 v.t. on SP1 and was sampled along the Rocky River in Jasper.

Table 338 Stand (SJ8063) illustrating the lodgepole pine/Labrador tea (C29) v.t. of the SP1 Ecosite.

TREE LAYER	
Pinus contorta	19
Picea engelmannii	03
SHRUB LAYER	
Ledum groenlandicum	38
Menziesia glabella	02
Pinus contorta	.5
Picea engelmannii	06
Shepherdia canadensis	06
HERB-DWARF SHRUB LAYER	
Arnica cordifolia	02
Cornus canadensis	06
Elymus innovatus	03
Epilobium angustifolium	.5
Hedysarum alpinum	.5
Linnaea borealis	15
Petasites palmatus	.5
Pyrola secunda	01
Vaccinium caespitosum	03
BRYOID LAYER	
Bryoria lanestris	.5
Cetraria canadensis	.5
Cladonia cornuta	.5
Cladonia gonecha	.5
Cladonia gracilis	.5
Dicranum fuscescens	.5
Hylocomium splendens	20
Peltigera aphthosa	03
Plagiothecium laetum	.5
Pleurozium schreberi	25
Ptilium crista-castrensis	20
Usnea alpina	.5
Lophozia spp.	.5
Ptilidium pulcherrimum	01
EPIPHYTES	
Bryoria glabra	.5
Cetraria merrillii	.5
Cetraria pinastri	.5
Hypogymnia austerodes	.5
Hypogymnia enteromorpha	.5
Hypogymnia physodes	.5
Letharia vulpina	.5
Parmelia sulcata	.5
Parmeliopsis ambigua	.5
Parmeliopsis hyperopta	.5
Platismatia glauca	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The SP1 Ecosite has the same characteristics as the dry portion of the Merlin Castle 1 (MC1) Ecosite, but can be distinguished because MC1 is characterized by a wet > dry landscape. The Rocky 1 (RK1) Ecosite is the Montane counterpart of SP1.

SX - SPHINX ECOSECTION

The Sphinx Ecosection is complex and encompasses moist to wet, seepage affected, morainal landforms throughout the Upper Subalpine portion of the Subalpine Ecoregion in Banff and Jasper. Inclined, ridged and hummocky surface expressions with low (gentle) internal relief are characteristic and usually reflect bedrock control. The moraines consist predominantly of noncalcareous, medium textured till (Till B) or calcareous, medium textured till (Till C). Thin discontinuous veneers of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A), derived locally from morainal and other postglacial deposit sources, form the subdominant landform of SX.

A complex set of genetically related Gleysolic, gleyed Podzolic and gleyed Brunisolic soils characterizes the SX Ecosection. Distribution of these soils is related to degrees of gleying and saturation, geomorphic activity and the the presence of primary mineral-bearing, surface veneers. Vegetation characterizing SX reflects varying seepage conditions and includes moist herb meadow, dwarf shrub-herb meadow, heath tundra, moist shrub thicket, wet shrub thicket, and moist Engelmann spruce-subalpine fir open forest. The three SX Ecosites are differentiated primarily by vegetation pattern differences — meadow versus open forest versus shrub vegetation as outlined in Table 339. The environmental factors controlling these vegetational differences are complex and not well understood.

The soil and vegetation pattern of the Sphinx Ecosection reflect moist to wet conditions (imperfect to poor drainage) attributable to seasonal and episodic seepage. Duration, frequency and rate of flow are variable but all SX tracts experience at least one major seepage event following snow melt and soil thaw in the spring. Water moves through the soil control section and over the surface early in the summer season (Plate 162). Over the summer, the soil surface becomes progressively drier and the depth to the apparent water table (free water) increases on most localities. Seepage and seeps, features of groundwater discharge, occur only sporadically on SX, being less common than on the Consolation Valley (CV) Ecosection.

Physiographic position is one factor that in-

Table 339 General features of the Sphinx (SX) Ecosites.

Ecosite	Landform	Soils	Vegetation
SX1	Till B; blanket > Fluviolacustrine material A; veneer	Gleysolic, gleyed Podzolic, gleyed Brunisolic	moist herb meadow, dwarf shrub-herb meadow > heath tundra, wet shrub thicket
SX2	Till B,C; blanket > Fluviolacustrine material A; veneer	Gleysolic, gleyed Podzolic, gleyed Brunisolic	moist Engelmann spruce-subalpine fir open forest
SX3	Till B,C; blanket > Fluviolacustrine material A; veneer	Gleysolic, gleyed Podzolic, gleyed Brunisolic	moist shrub thicket, wet shrub thicket

fluences seepage conditions on SX. The SX Ecosection occurs on floors (including benchlands), walls and shoulders within valleys, cols and cirques (Figures 39, 48, 53 and 54). Plate 163 shows SX1 on the floor and SX2 on the lower slopes of Miette (Centre) Pass in Jasper. Gentle slopes and shallow morainal deposits, usually overlying shaly and slaty bedrock, commonly characterize these positions. Distribution of SX within Banff and Jasper is related to bedrock. It is most abundant and extensive in the Main Ranges in areas underlain by Miette Group strata. These are dominantly flat lying slates and shales. Landscape position in these areas includes walls, floors and shoulders within valleys, cols and cirques. The SX Ecosection is less common in areas underlain by Mesozoic shales and sandstones and is of limited distribution in areas dominated by limestone, dolomite and quartzite bedrock. In these areas, its position is usually confined to floor and benchland positions within valleys, cols and cirques.

SX1 - SPHINX 1 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, SX1, encompasses moist to wet morainal landforms dominated by meadow vegetation. Morainal blankets, consisting predominantly of noncalcareous, medium textured till (Till B), overlying inclined, hummocky and ridged bedrock are typical. Thin, discontinuous veneers of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) are subdominant.

A complex set of genetically related soils, best represented by the Orthic Gleysol, Rego Gleysol, Gleyed Ferro-Humic Podzol and Gleyed Dystric Brunisol Subgroups, characterizes SX1. Vegetation is also complex and reflects several interacting factors. The vegetation pattern which best characterizes SX1 is one in which the fleabane-valerian (H16) and arctic willow-cinquefoil (L7) v.t.s are dominant and the heather-everlasting (L5) and willow/cinquefoil (S8) v.t.s are subdominant.

The SX1 Ecosite is the most extensive of the three SX Ecosites. It is most abundant in the Main Ranges in areas underlain by Miette Group strata. Because of the bedrock structure and resultant landscape, SX1 occurs on several physiographic positions including floors, benchlands, slopes and shoulders within valleys, cols and cirques. The SX1 Ecosite occurrences are infrequent in areas underlain by other bedrock types.

Geomorphology

The SX1 Ecosite is typified by morainal blankets consisting of noncalcareous, medium textured till (Till B) overlying inclined, hummocky and ridged bedrock. Thin, discontinuous veneers of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) are common and overlie the till on a variety of slopes and landscape positions. The fluviolacustrine material was derived locally by sheet erosion of morainal surfaces and reworking of postglacial eolian deposits, namely Eolian material B. Intact veneers of Eolian material B occur sporadically and are most abundant in western Banff and southwestern Jasper. In several localities, the till and surface veneers have been mixed by solifluction processes. Calcareous, medium textured till (Till C) occurs locally on some tracts and dominates a few. Noncalcareous, coarse textured till (Till A) rarely occurs on tracts mapped as SX1. Thin fluvial deposits, usually noncalcareous, coarse, stratified fluvial material (Fluvial material A), are associated with intermittent and permanent streams that dissect the landscape. These are often underlain by till and capped by fluviolacustrine deposits.

Topographically, SX1 displays linear, ridged and hummocky surface forms with low internal relief. Slopes commonly range between 5 and 30% but gradients <5% occur locally on depressional sites. A few unusually steep localities have slopes ranging to 35%. Surface form usually reflects the underlying bedrock although slope failure has produced irregular topography in a few cases. Morainal veneers

and bedrock outcrops occur rarely. Shallow dissection and channel construction by intermittent and permanent streams has added to slope irregularity in several instances. Lobe, stream and bench manifestations of solifluction are generally unobtrusive.

Soils

Soil distribution on SX1 is complex and related to degrees of gleying and saturation, geomorphic activity and the presence of primary mineral-bearing, surface veneers. The Orthic Gleysol, Rego Gleysol, Gleyed Ferro-Humic Podzol and Gleyed Dystric Brunisol Subgroups with imperfect to poor drainage best represent SX1 soils. Strength of gleying, reflecting rate of flow and aeration of seepage waters, is variable. Long periods of saturation, recent and continuing fluvial or fluviolacustrine deposition and severe solifluction or cryoturbation retard or destroy pedogenic horizonation (Rego Gleysols). Saturation is the most important of these factors, hence Rego Gleysols exhibiting strong gley characteristics are abundant on the wettest, usually depressional, localities. Orthic Gleysols, Gleyed Ferro-Humic Podzols and Gleyed Dystric Brunisols occur on localities with shorter periods of saturation allowing B horizon development. The presence of eolian and fluviolacustrine veneers containing primary minerals promotes the development of iron, aluminum and humus enriched B and podzolic B horizons (usually Bhf and podzolic Bhf). Soils with these strongly developed B horizons occur under both imperfectly and poorly drained conditions and are most abundant in western Banff and southwestern Jasper. Many SX1 soils have thin (<10 cm) organo-mineral, surface horizons with or without some evidence of eluviation. These reflect the near Alpine conditions and vegetation. Peaty surface layers are common only on the wettest sites and are not generally associated with the dominant or subdominant v.t.s other than willow/cinquefoil (S8). A pedon illustrating Orthic Gleysols of SX1 is described in Table 340 and shown in Color Plate 70.

Soils with well developed eluvial (Ae) horizons (Gleyed Eluviated Dystric Brunisols) and organo-mineral horizons (Ah) > 10 cm thick (Orthic Humic Gleysols, Gleyed Sombric Brunisols) are accessory soils. In several cases, the Ah horizons have been physically thickened by solifluction. Turbic phase applies to soils that display physical thickening, disruption and mixing of horizons in upper sola by solifluction.

Minor amounts of several soils occur on SX1. Soils lacking B horizons include Rego Humic Gleysols and various gleyed Regosolic soils. Terric Mesisols occur occasionally on ponded sites. Dry (moderately well drained), generally convex sites, have Orthic Dystric Brunisols, Eluviated Dystric Brunisols and Orthic Ferro-Humic Podzols. Where calcareous, medium textured till (Till C) is present the soils have higher pH's throughout their sola; those with B horizons and weak gleying are Gleyed Eutric Brunisols, Gleyed Eluviated Eutric Brunisols and Gleyed Melanic Brunisols. Lithic soil phases occur rarely but soils developed in shallow till overlying noncalcareous, medium textured residuum (Residuum A) do occur.

Vegetation

Vegetation of the SX1 Ecosite is complex and reflects several interacting factors, one of the more important being degree of seepage (wetness). The vegetation pattern which best typifies SX1 is one in which the fleabane-valerian (H16) and arctic willow-cinquefoil (L7) v.t.s are dominant, and heather-everlasting (L5) and willow/cinquefoil (S8) are subdominant. Of the above H16 is most abundant and extensive and reflects varying seepage conditions. Several tracts are dominated by L7, primarily in central regions of Banff and Jasper, spanning both the Main and Front Ranges. The L7 v.t. also occurs in localities that receive episodic seepage. The L5 v.t. occurs frequently but has low areal extent. It forms patches and strips on slightly elevated, convex sites with better drained soils than the surrounding H16 and L7 dominated landscape. Seepage seasonally affects the sola of the soils under L5, following snow melt and soil thaw. During the remainder of the summer season, the apparent water table remains well below the soil surface and, during dry years, below the control section. Also, S8 occurs frequently but has low areal extent. It favors depressional, poorly drained sites, especially those with fluvial deposits along intermittent and permanent streams. A plot representing vegetation of the pedon sample site (Table 340) and illustrating H16 on SX1 is presented in Table 341 and Plate 164.

Important accessory v.t.s on SX1 are black alpine sedge-everlasting (H2) and mountain marigold-globeflower (H9). The H2 v.t. occurs in small patches that have late snow melt. Like S8, H9 is common along small streams in depressional, poorly drained, seepage collection sites. Willow-dwarf birch/fleabane (S4) occurs occasionally in minor amounts. Other v.t.s occurring in minor amounts are forested sites with subalpine larch-subalpine fir/grouseberry-everlasting (C23), Engelmann spruce-subalpine fir/valerian-fleabane (O9), Engelmann spruce-subalpine fir/heather (O10), and ponded sites with cottongrass/moss (H10) or water sedge-beaked sedge (H11). Modification of vegetation by avalanching (tracts mapped as SX1A) occurs infrequently.

Table 340 Pedon (Alberta 1979 No. 40) description of an Orthic Gleysol of the SX1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC GLEYSOL, SOIL MAP UNIT: NOTATION: SX1.

LOCATION: MILITARY GRID REF. 11 UL/ 6935 7475; NTS MAP AREA 83E 2E.

CLIMATE: 1978 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 12 DEGIC) AT 50 CM IN AUGUST.

VEGETATION: VPN=LC9387PVTH=K16.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), MEDIUM ACID TO NEUTRAL (PH 5.0-7.3), MORAINAL (TILL), SEDIMENTARY; LANDFORM CLASSIFICATION: MORAINAL, HUMMOCKY; SLOPE: 9% COMPLEX SLOPE OF CLASS 4 (6-9%), FACING NORTHEAST, SITE AT MIDDLE POSITION, STRONGLY MOUNDED MICROTOPOGRAPHY.; SOIL MOISTURE AND DRAINAGE: IMPERFECTLY DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE PRESENT; VERY STONY; PRESENT LAND USE: ALPINE.

SPECIAL NOTES: SBM=BC90614APM=018-017=PCF=2GR(1)2GR,1CB,197(E-6)=DATE=AUG.26,1979=

AHE: 0 TO 14 CM, RANGE 12 TO 17 CM; MATRIX MOIST 10YR 4/3, MATRIX DRY 10YR 6/3; LOAM; STRONG, FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, FINE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BMGJ: 14 TO 44 CM, RANGE 06 TO 33 CM; MATRIX MOIST 10YR 5/4; LOAM; COMMON, FINE, PROMINENT, 7.5YR 6/8 MOTTLES; MODERATE, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; FEW, VERY FINE PORES; FEW, VERY THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; WAVY, GRADUAL HORIZON BOUNDARY; STRONGLY ACID 5.1-5.5 FIELD PH.

CG1: 44 TO 70 CM, RANGE 30 TO 40 CM; MATRIX MOIST 5Y 5/2; LOAM; MANY, MEDIUM, PROMINENT, 10YR 5/8 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; FIRM CONSISTENCE; FEW, FINE ROOTS; FEW, VERY FINE PORES; FEW, VERY THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY; WAVY, DIFFUSE HORIZON BOUNDARY.

CG2: 70 TO 100 CM; MATRIX MOIST 2.5Y 5/2; SANDY LOAM; MANY, COARSE, DISTINCT, 2.5Y 6/4 MOTTLES; FEW, FINE, PROMINENT, 5YR 5/8 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSIST[illegible] FEW, VERY FINE PORES; FEW, VERY THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
AHE	4.1	5.20	19.8		2.9	1.0	0.2	0.3
BMGJ	4.5	0.60	5.1		0.2	0.0	<.1	0.1
CG1	5.2		4.4		1.6	0.5	0.1	0.1
CG2	6.2		2.7		1.9	0.5	<.1	0.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2
AHE				
BMGJ	0.4		0.1	
CG1				
CG2				

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS % PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-.01 MM SILT	.01-.005 MM SILT	.005 CLAY	.005 CLAY	BULK DENS G/CC
AHE					4	7	9	8	6	34		48	18		0.90
BMGJ					8	16	9	11	9	44		44	12		1.70
CG1					8	8	10	10	6	39		44	17		
CG2		99	99	93	98	10	14	11	12	6	53		37	10		1.10

PHYSICAL DATA

ENGINEERING

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AHE								
BMGJ								
CG1								
CG2	0.0	14.0					40	10

Discussion

The SX1 Ecosite encompasses moist to wet morainal landforms dominated by meadow vegetation in the Upper Subalpine. In a broad sense, SX1 resembles the Egypt 4 (EG4) Ecosite but the dominantly well and moderately well drained soils and mesic vegetation of EG4 allow it to be differentiated from the imperfectly and poorly drained soils and associated vegetation of SX1. Wet segments of the Egypt 3 (EG3) Ecosite often resemble SX1. However, in contrast to SX1, EG3 has a compound dry > wet landscape pattern with attendant differences in soil and vegetation. The SX2 and SX3 v.t.s are differentiated from SX1 by vegetation differences as outlined in Table 339.

Table 341 Stand (LC9167) illustrating the fleabane-valerian (H16) v.t. of the SX1 Ecosite.

	HERB-DWARF SHRUB LAYER
Agoseris aurantiaca	01
Anemone occidentalis	02
Antennaria lanata	03
Arnica alpina	02
Arnica mollis	03
Artemisia norvegica	10
Caltha leptosepala	01
Carex nigricans	02
Carex spectabilis	05
Deschampsia atropurpurea	02
Epilobium spp.	01
Erigeron peregrinus	.5
Juncus balticus	03
Leptarrhena pyrolifolia	.5
Luetkea pectinata	01
Luzula spicata	03
Mitella pentandra	.5
Pedicularis bracteosa	02
Phleum alpinum	01
Senecio triangularis	10
Stellaria calycantha	.5
Trollius albiflorus	04
Valeriana sitchensis	10
Veratrum eschscholtzii	.5
Veronica alpina	.5
Equisetum arvense	.5
	BRYOID LAYER
Aulacomnium palustre	40
Brachythecium nelsonii	01
Bryum pseudotriquetrum	01
Cladonia pleurota	.5
Cladonia spp.	.5
Drepanocladus uncinatus	02
Hypnum spp.	.5
Philonotis fontana	.5
Pohlia spp.	.5
Polytrichum strictum	05
Rhacomitrium canescens	.5
Rhizocarpon geographicum	.5
Rhytidiadelphus squarrosus	.5
Lophozia floerkii	.5
Scapania spp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

SX2 - SPHINX 2 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, SX2, encompasses moist to wet morainal landforms dominated by open forest. Morainal blankets overlying inclined bedrock are typical. Noncalcareous, medium textured till (Till B) is the most common constituent of these moraines but several tracts are composed of calcareous, medium textured till (Till C). Weakly calcareous tills with characteristics intermediate between Till B and Till C are common. Thin, discontinuous veneers of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) are subdominant.

A complex set of genetically related soils, best represented by the Orthic Gleysol, Rego Gleysol, Gleyed Ferro-Humic Podzol and Gleyed Dystric Brunisol Subgroups, characterizes SX2. Vegetation is also complex and reflects, in the main, degree of seepage. A pattern in which the Engelmann spruce-subalpine fir/valerian-fleabane (O9) v.t. is dominant and Engelmann spruce-subalpine fir/heather (O10) is subdominant characterizes SX2.

SX2 is most abundant in areas underlain by Miette Group strata and less extensive in areas dominated by other bedrock types. It is usually confined to lower slopes and floors within Upper Subalpine valleys, cirques and cols.

Geomorphology

The SX2 Ecosite is typified by morainal blankets overlying inclined bedrock. Noncalcareous, medium textured till (Till B) is the most common constituent of these moraines but several tracts are composed of calcareous, medium textured till (Till C). Noncalcareous, coarse textured till (Till A) occurs rarely. Thin, discontinuous veneers of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) are common and overlie the till on a variety of slopes and landscape positions. The fluviolacustrine material was derived locally by sheet erosion of morainal surfaces and reworking of postglacial eolian deposits, Eolian material B. Intact veneers of Eolian material B occur sporadically and are most abundant in western Banff and southwestern Jasper. In several localities, the till and surface veneers have been mixed by solifluction processes. Many SX2 tracts span valley floors containing well-established streams. Fluvial deposits, either noncalcareous, coarse, stratified fluvial material (Fluvial material A) or calcareous, coarse, stratified fluvial material (Fluvial material B), are associated with the stream channels. Ice contact stratified drift, usually noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A), also occurs occasionally along valley floor positions. One notable area, in the upper Miette River valley between Centre Pass and Miette Lake, includes a few SX2 tracts consisting of shallow, nearly continuous, noncalcareous, fine textured, glaciolacustrine material overlying medium textured, slightly stratified till plus well-sorted glaciofluvial sands and gravels.

Topographically, SX2 most often displays linear, inclined slopes that reflect underlying bedrock. Hummocky surfaces, reflecting underlying bedrock or slope failure, also occur occasionally. Slopes commonly range from 5 to 45% but gradients <5% occur locally along stream channels on valley floors. Several tracts include opposing, inclined, lower valley wall slopes plus the stream and its channel deposits between them. Morainal veneers and bedrock outcrops occur rarely. Lobe, stream and bench manifestations of solifluction are generally unobtrusive.

Table 342 Pedon (Alberta 1979 No. 46) description of a Gleyed Dystric Brunisol of the SX2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: GLEYED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: SX2.

LOCATION: MILITARY GRID REF. 11 UHJ 1330 4325; NTS MAP AREA 830 9*.

CLIMATE: 1900 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 6 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=PA9126*VTN=09*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<10% CLAY), MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), MORAINAL (TILL), SEDIMENTARY; LANDFORM CLASSIFICATION: MORAINAL, SILTY, INCLINED; SLOPE: 7% SIMPLE SLOPE OF CLASS 4 (6-9%), FACING SOUTHWEST, SITE AT MIDDLE POSITION, STRONGLY MOUNDED MICROTOPOGRAPHY.; SOIL MOISTURE AND DRAINAGE: IMPERFECTLY DRAINED, SLOWLY PERVIOUS, SLOW SURFACE RUNOFF, SEEPAGE PRESENT; MODERATELY STONY.

SPECIAL NOTES: SSN=GC9067*APH=015-023*PCF=1GR,1CB(2-5)*DATE=SEPT.8,1979*

H: 7 TO 0 CM, RANGE 5 TO 12 CM; MATRIX MOIST 10YR 2/1; ABUNDANT, VERY FINE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BMGJ1: 0 TO 9 CM, RANGE 8 TO 11 CM; MATRIX MOIST 10YR 4/4; LOAM; MANY, FINE, DISTINCT, 7.5YR 4/6 MOTTLES; MODERATE, FINE, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; VERY FEW, VERY FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

BMGJ2: 9 TO 24 CM, RANGE 10 TO 14 CM; MATRIX MOIST 10YR 4/3; LOAM AND SANDY LOAM; MANY, FINE, PROMINENT MOTTLES; 7.5YR 4/6 MOTTLES; MODERATE, FINE, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, VERY FINE ROOTS; VERY FEW, VERY FINE PORES; WAVY, GRADUAL HORIZON BOUNDARY.

CGJ1: 24 TO 80 CM, RANGE 50 TO 60 CM; MATRIX MOIST 2.5Y 4/4; LOAM AND SANDY LOAM; MANY, FINE, PROMINENT, 7.5YR 4/4 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, VERY FINE PORES; COMMON, VERY THIN CLAY FILMS IN VOIDS AND/OR CHANNELS ONLY AND ON PED FACES-UNSPECIFIED; WAVY, DIFFUSE HORIZON BOUNDARY.

CGJ2: 80 TO 110 CM; MATRIX MOIST 10YR 4/3; LOAM; MANY, MEDIUM, DISTINCT, 7.5YR 4/4 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; .

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
H	5.2	30.00						
BMGJ1	5.2	1.20	6.5		3.0	0.7	0.1	0.1
BMGJ2	5.3	0.60	4.3		2.0	0.5	0.1	<.1
CGJ1	5.2		2.7		1.2	0.2	0.0	<.1
CGJ2	5.5		3.3		1.8	0.3	<.1	<.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
H				
BMGJ1	0.4		<.1	
BMGJ2	0.3		<.1	
CGJ1				
CGJ2				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
H															
BMGJ1					8	13	12	12	5	50		28	22		1.70
BMGJ2					7	11	13	14	7	51		42	7		
CGJ1					5	9	11	15	9	49		44	7		
CGJ2		99	92	81	77	7	10	12	15	7	51		40	9	2.00

PHYSICAL DATA

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
H								
BMGJ1								
BMGJ2								
CGJ1								
CGJ2	17.0	19.0		13.0	1.8		A8	87

Soils

Soil distribution on SX2 is complex and related to degrees of gleying and saturation, geomorphic activity and the presence of primary mineral-bearing, surface veneers. The Orthic Gleysol, Rego Gleysol, Gleyed Ferro-Humic Podzol and Gleyed Dystric Brunisol Subgroups with imperfect to poor drainage best represent SX2 soils. Strength of gleying, reflecting rate of flow and aeration of seepage waters, is variable. Long periods of saturation, recent and continuing fluvial or fluviolacustrine deposition, and severe solifluction or cryoturbation retard or destroy pedogenic horizonation (Rego Gleysols). Saturation is the most important of these factors, hence Rego Gleysols exhibiting strong gley characteristics are abundant on the wettest localities. Orthic Gleysols, Gleyed

Ferro-Humic Podzols and Gleyed Dystric Brunisols occur on localities with shorter periods of saturation allowing B horizon development. The presence of eolian and fluviolacustrine veneers containing primary minerals promotes the development of iron, aluminum and humus enriched B and podzolic B horizons (usually Bhf). Soils with these strongly developed B horizons occur under both imperfectly and poorly drained conditions and are most abundant in western Banff and southwestern Jasper. Most SX2 soils have thin organic (peaty) layers at the surface rather than the Ah horizon common to SX1 soils. A pedon illustrating Gleyed Dystric Brunisols of SX2 is described in Table 342 and shown in Color Plate 71.

Gleyed Eutric Brunisols are important accessory soils and replace Gleyed Dystric Brunisols on localities and tracts dominated by calcareous, medium textured till (Till C). Soils with well developed eluvial (Ae) horizons (Gleyed Eluviated Dystric, and to a lesser extent, Eutric Brunisols) are important on imperfectly drained localities. Turbic phases have upper sola horizons that have been physically thickened, disrupted, or mixed by solifluction. Other soils occurring occasionally include Orthic and Eluviated Dystric and Eutric Brunisols and Orthic Humo-Ferric Podzols of dry (moderately well drained), generally convex sites, Terric Mesisols of ponded sites, and Humic Gleysols and gleyed Regosolic soils of imperfectly to poorly drained, often disturbed or eroded localities. Lithic soil phases occur rarely but soils developed in shallow till overlying noncalcareous, medium textured residuum (Residuum A) do occur.

Vegetation

Vegetation of the SX2 Ecosite is complex and reflects, in the main, degree of seepage (wetness). A pattern in which the Engelmann spruce-subalpine fir/valerian-fleabane (O9) v.t. is dominant and the Engelmann spruce-subalpine fir/heather (O10) v.t. subdominant, best typifies SX2 vegetation. The O9 v.t. is more extensive and reflects a range of seepage conditions. Although it only occupies a small part of the landscape, O10 occurs frequently in patches and strips on slightly elevated, convex sites with better drained soils than the surrounding O9 dominated landscape. Seepage occasionally affects sola of the soils under following snow melt and soil thaw. During the remainder of the summer season, the apparent water table remains well below the soil surface and, during dry years, below the control section. A plot representing vegetation of the pedon sample site (Table 342) and illustrating O9 on SX2 is presented in Table 343 and Plate 165.

Important accessory v.t.s of SX2 are Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6), Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14), fleabane-valerian (H16) and willow/cinquefoil (S8). The O6 and O14 v.t.s occur at low elevations within the Upper Subalpine, usually on well protected, valley floor positions with poorly drained soils. The O6 and S8 v.t.s usually occur on fluvial deposits along stream channels, whereas O14 occurs most often on moraines. The H16 v.t. occurs on small, usually exposed localities. Several v.t.s occur in minor amounts, including closed forest with subalpine larch-subalpine fir/grouseberry-everlasting (C23), Engelmann spruce-subalpine fir/

Table 343 Stand (PA9126) illustrating the Engelmann spruce-subalpine fir/valerian-fleabane (09) v.t. of the SX2 Ecosite.

TREE LAYER	
Picea engelmannii	15
TALL SHRUB LAYER	
Picea engelmannii	.5
SHRUB LAYER	
Picea engelmannii	.5
HERB-DWARF SHRUB LAYER	
Agoseris glauca	.5
Arnica spp.	01
Artemisia norvegica	30
Aster spp.	.5
Calamagrostis canadensis	.5
Deschampsia atropurpurea	03
Erigeron peregrinus	10
Pedicularis bracteosa	05
Petasites sagittatus	.5
Polygonum viviparum	.5
Senecio triangularis	05
Trollius albiflorus	20
Vaccinium scoparium	.5
Viola renifolia	.5
BRYOID LAYER	
Aulacomnium palustre	40
Campylium stellatum	03
Cladonia arbuscula	05
Cladonia bellidiflora	02
Cladonia carneola	.5
Cladonia coccifera	.5
Cladonia deformis	02
Cladonia ecmocyna	06
Cladonia gonecha	05
Dicranum scoparium	03
Dicranum spadiceum	.5
Ditrichum flexicaule	02
Drepanocladus uncinatus	02
Hylocomium splendens	05
Peltigera aphthosa	02
Polytrichum strictum	.5
Tomenthypnum nitens	.5
Barbilophozia hatcheri	.5
Barbilophozia lycopodioides	05
Lophozia spp.	.5
EPIPHYTES	
Alectoria sarmentosa	.5
Bryoria fremontii	.5
Bryoria simplicior	.5
Calicium viride	.5
Hypogymnia austerodes	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

grouseberry (C15), Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21); ponded sites with cottongrass/moss (H10) or water sedge-beaked sedge (H11); and stream channel sites with mountain marigold-globeflower (H9). Mountain avens-snow willow-moss campion (H1) with tree islands is common on severely soliflucted slopes associated with Mesosoic strata in eastern Banff and Jasper. Modification of vegetataion by avalanching (mapped as SX2A) occurs occasionally.

Discussion

The SX2 Ecosite encompasses moist to wet morainal landforms dominated by open forest in the Upper Subalpine. It resembles the Consolation Valley 1 (CV1) Ecosite which is its Lower Subalpine counterpart. The CV1 Ecosite, in contrast to SX2, has a compound wet > dry landscape pattern with soils and vegetation of its wet segments reflecting the Lower Subalpine and wetter, groundwater discharge conditions. Wet segments of the Egypt 3 (EG3) Ecosite often resemble SX2, but EG3 has a compound dry > wet landscape pattern with attendant differences in soil and vegetation which serve to differentiate it from SX2 Ecosites. The SX1 and SX3 Ecosites are differentiated from SX2 by vegetation differences as outlined in Table 339.

SX3 - SPHINX 3 ECOSITE

Ecosite Concept

The Upper Subalpine SX3 Ecosite encompasses moist to wet morainal landforms dominated by shrub vegetation. Morainal blankets, consisting of noncalcareous, medium textured till (Till B) or calcareous, medium textured till (Till C), overlying inclined, hummocky and ridged bedrock are typical. Thin, discontinuous veneers of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) are subdominant.

A complex set of genetically related soils, best represented by the Orthic Gleysol, Rego Gleysol, Gleyed Ferro-Humic Podzol and Gleyed Eutric Brunisol Subgroups, characterizes SX3. Moist to wet shrub vegetation, best represented by willow-dwarf birch/fleabane (S4) and willow/cinquefoil (S8) typifies SX3. The v.t. distribution reflects degrees of wetness as influenced by seepage.

The SX3 Ecosite is the least extensive of the SX Ecosites. Its occurrence is frequently related to medium and fine grained clastic bedrock of Paleozoic and Mesozoic age. Consequently, SX3 is most extensive in the central and eastern regions of both parks including both the Main and Front Ranges. There are a few occurrences in central to western areas which are underlain by the Miette Group. The SX3 Ecosite is usually confined to lower slope, floor and benchland positions within valleys, cirques and cols of the Upper Subalpine. Occasionally, it occurs on shoulder positions.

Geomorphology

The SX3 Ecosite is typified by morainal blankets consisting of noncalcareous, medium textured till (Till B) or calcareous, medium textured till (Till C) overlying inclined, hummocky and ridged bedrock. Weakly calcareous mixtures of the two tills are common. Thin, discontinuous veneers of altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) are common and overlie the till on a variety of slopes and landscape positions. The fluviolacustrine material was derived locally by sheet erosion of morainal surfaces and reworking of postglacial eolian deposits (Eolian material B). Intact veneers of Eolian material B occur sporadically and are most abundant in western Banff and southwestern Jasper. In several localities, the till and surface veneers have been mixed by solifluction processes. Thin fluvial deposits, including both noncalcareous, coarse, stratified fluvial material (Fluvial material A) and calcareous, coarse, stratified fluvial material (Fluvial material B), are associated with intermittent and permanent streams that dissect the landscape. These are often underlain by till and capped by fluviolacustrine deposits.

Topographically, SX3 displays linear, ridged and hummocky surface forms with low internal relief. Slopes commonly range between 5 and 30% but gradients <5% occur locally on depressional sites. Surface form usually reflects the underlying bedrock although slope failure has produced irregular topography in a few cases. Morainal veneers and bedrock outcrops occur rarely. Shallow dissection and channel construction by intermittent and permanent streams has added to slope irregularity in several instances. Lobe, stream and bench manifestations of solifluction are unobtrusive.

Soils

Soil distribution on SX3 is complex and related to degrees of gleying and saturation, geomorphic activity, and the presence of primary mineral-bearing, surface veneers. The Orthic Gleysol, Rego Gleysol, Gleyed Ferro-Humic Podzol and Gleyed Eutric Brunisol Subgroups with imperfect to poor drainage best represent SX3 soils. Strength of gleying, reflecting degree of movement and aeration of seepage waters, is variable. Long periods of saturation, recent and continuing fluvial or fluviolacustrine deposition, and se-

Table 344 Pedon (Alberta 1978 No. 56) description of a gleyed Podzolic soil of the SX3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC HUMIC PODZOL. SOIL MAP UNIT: NOTATION: SX3.

LOCATION: MILITARY GRID REF. 11 UNH 6280 250; NTS MAP AREA 82N 8E.

CLIMATE: 2210 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS MODERATE RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPH=PAS1B4+VTH=B1+..

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), UNDIFFERENTIATED, FLUVIOLACUSTRINE, SEDIMENTARY; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (4-40% CACO3), MORAINAL (TILL), SEDIMENTARY; LANDFORM CLASSIFICATION: MORAINAL, HUMMOCKY; SLOPE: 6% COMPLEX SLOPE OF CLASS 4 (4-9%), FACING WEST, SITE AT LOWER SLOPE POSITION, MODERATELY MOUNDED MICROTOPOGRAPHY,200 M LONG; SOIL MOISTURE AND DRAINAGE: POORLY DRAINED, MODERATELY PERVIOUS, SLOW SURFACE RUNOFF, SEEPAGE PRESENT, 0.3 M TO APPARENT WATERTABLE; SLIGHTLY STONY.

SPECIAL NOTES: SSN=SC6036+APH=783-10+PCF=1CB(1-3),1BR(5-6)+

H: 9 TO 0 CM, RANGE 7 TO 10 CM; MATRIX MOIST 10YR 2/1; ABUNDANT, FINE ROOTS; FEW, VERY FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

AH: 0 TO 9 CM, RANGE 7 TO 9 CM; MATRIX MOIST 7.5YR 4/2; SILTY CLAY LOAM; DISTINCT, 5YR 3/3 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; WEAK, FINE, GRANULAR SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; FEW, FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

BH: 9 TO 19 CM, RANGE 7 TO 11 CM; MATRIX MOIST 5YR 4/8; SILT LOAM; WEAK, COARSE, SUBANGULAR BLOCKY STRUCTURE; MODERATE, FINE, SUBANGULAR BLOCKY SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; MANY, FINE PORES; WAVY, ABRUPT HORIZON BOUNDARY.

BCG: 19 TO 20 CM, RANGE 1 TO 2 CM; MATRIX MOIST 10YR 2/1, MATRIX MOIST 10YR 3/2; SILT LOAM; MODERATE, FINE, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE ROOTS; MANY, FINE PORES; WAVY, ABRUPT HORIZON BOUNDARY.

2BCGJ: 20 TO 46 CM, RANGE 14 TO 21 CM; MATRIX MOIST 10YR 5/4; SILTY CLAY LOAM; COMMON, FINE, DISTINCT, 7.5YR 6/6 MOTTLES; STRUCTURELESS, FINE, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; FEW, VERY FINE PORES; COBBLY AND GRAVELLY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2CKG: 46 TO 74 CM; MATRIX MOIST 2.5Y 5/4; SILT LOAM; MANY, MEDIUM, PROMINENT, 7.5YR 6/8 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE PORES; MODERATE EFFERVESCENCE; MODERATELY CALCAREOUS; COBBLY AND GRAVELLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
H	5.6	10.00		96.9		58.2	9.3	0.1	0.4
AH	5.6	8.70		65.9		30.2	4.9	0.1	0.2
BH	6.0	5.70		35.8		18.5	2.3	0.1	0.1
BCG									
2BCGJ	6.6		0.4	14.9		10.6	2.3	-.1	0.2
2CKG	7.2		12.1						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
H				
AH				
BH	0.2		0.4	
BCG				
2BCGJ				
2CKG				

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
H										3		34	63		0.90
AH										11		57	32		
BH										17		72	11		0.70
BCG															
2BCGJ										12		66	32		1.80
2CKG	99	82	75	73						10		73	17		1.80

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
H													
AH		90.5	12.0										
BH													
BCG													
2BCGJ		52.4	7.7										
2CKG		89.8	7.9			19.8	26.0		17.8	1.7		48	19

vere solifluction or cryoturbation retard or destroy pedogenic horizonation resulting in Rego Gleysols. Saturation is the most important of these factors, hence Rego Gleysols exhibiting strong gley characteristics are abundant on the wettest, usually depressional, localities. Orthic Gleysols, Gleyed Ferro-Humic Podzols and Gleyed Eutric Brunisols occur on localities with shorter periods of saturation, allowing B horizon development. The presence of eolian and fluviolacustrine veneers containing primary minerals promotes the development of iron, aluminum and humus enriched B and podzolic B horizons (usually Bhf). Soils with these strongly developed B horizons occur under both imperfectly and poorly drained conditions and are most abundant in western Banff and southwestern Jasper. Soils of SX3 have, at their surfaces, peaty layers and/or thin (<10 cm) organo-mineral (Ah) horizons.

A pedon illustrating gleyed Podzolic soils of SX3 is described in Table 344 and shown in Color Plate 72. The sample site is shown in Plate 166. This profile's B horizon meets all criteria for a Bhf except ratio of organic carbon to pyrophosphate-extractable iron. Hence, the horizon is classed as Bh, the soil as Orthic Humic Podzol, but it is pedogenically related to the modal Gleyed Ferro-Humic Podzols.

Gleyed Dystric Brunisols are important accessory soils and often replace Gleyed Eutric Brunisols on localities and tracts dominated by noncalcareous, medium textured till (Till B). Soils with well developed eluvial (Ae) horizons (Gleyed Eluviated Eutric Brunisols) are important on imperfectly drained sites. Gleyed Melanic Brunisols, with thicker than normal (>10 cm) organo-mineral (Ah) horizons, occur locally under the Upper Subalpine conditions and shrub vegetation. In several cases, the Ah horizons have been physically thickened by solifluction. Turbic phase applies to soils that display physical thickening, disruption and mixing of horizons in upper sola by solifluction. Humic Gleysols occur in minor amounts in these geomorphically influenced sites. Other minor soils are Orthic and Eluviated Eutric Brunisols, Orthic and Eluviated Dystric Brunisols and Orthic Humo-Ferric Podzols of dry (moderately well drained), generally convex sites, Terric Mesisols of ponded sites, and gleyed Regosolic soils of imperfectly drained, disturbed and eroded localities. Lithic soil phases occur rarely.

Vegetation

Moist to wet shrub vegetation, best represented by the willow-dwarf birch/fleabane (S4) and willow/cinquefoil (S8) v.t.s, characterizes SX3. The distribution of v.t.s reflects degrees of wetness as influenced by seepage characteristics. The S4 v.t. tolerates a wider range of moisture regimes than S8 but tends to favor imperfectly drained soils with relatively dry surface conditions. The S8 v.t. occurs on the wetter localities. Willow/hairy wild rye (S12) is an accessory v.t. occurring on moderately well to imperfectly drained sites with dry surfaces. Dwarf birch-shrubby cinquefoil-willow/brown moss (S1) occurs as an accessory v.t. on poorly drained sites at low elevations in the Upper Subalpine. Several v.t.s occur in minor amounts including open forest with Engelmann spruce-subalpine fir/rock willow/alpine bearberry (O12), Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14), ponded sites with cottongrass/moss (H10) and water sedge-beaked sedge (H11), herb meadow patches with black alpine sedge-everlasting (H2) and fleabane-valerian (H16) and, in eastern regions, severely soliflucted sites with mountain avens-snow willow-moss campion (H1). Also, dwarf birch-willow/kobresia (S9) and willow/timber oatgrass (S11) may occasionally occur. A plot illustrating S4 on SX3 is described in Table 345.

Table 345 Stand (JD8113) illustrating the willow-dwarf birch/fleabane (S4) v.t. of the SX3 Ecosite.

TALL SHRUB LAYER	
Picea engelmannii	02
SHRUB LAYER	
Abies lasiocarpa	.5
Salix barrattiana	30
Salix glauca	60
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	.5
Agoseris glauca	.5
Agropyron latiglume	01
Anemone parviflora	01
Astragalus alpinus	.5
Castilleja occidentalis	01
Cerastium arvense	.5
Erigeron peregrinus	10
Gentiana propinqua	.5
Luzula wahlenbergii	.5
Pedicularis bracteosa	.5
Pedicularis groenlandica	01
Phleum alpinum	01
Poa alpina	.5
Potentilla diversifolia	05
Salix arctica	10
Senecio lugens	01
Sibbaldia procumbens	.5
Solidago multiradiata	.5
Trollius albiflorus	15
Valeriana sitchensis	10
Veronica alpina	01
Equisetum scirpoides	05
Equisetum variegatum	01
BRYOID LAYER	
Aulacomnium palustre	10
Dicranum spp.	10
Distichium capillaceum	05
Ditrichum flexicaule	10
Drepanocladus uncinatus	10
Peltigera aphthosa	.5
Tortula ruralis	20
Barbilophozia lycopodioides	05

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The SX3 Ecosite encompasses moist to wet morainal landforms dominated by shrub vegetation in the Upper Subalpine. In a broad sense, SX3 resembles the Tyrrell 1 (TR1) and Num-Ti-Jah 2 (NT2) Ecosites. Although TR1 has similar landforms to SX3, including genetic materials, its soils and vegetation reflect drier (well to moderately well drained) conditions with little or no seepage influence. The NT2 Ecosite has shrub vegetation similar to that of SX3 but is dominated by fluvial rather than morainal landforms. Where small wet portions of SX3 occur along stream channels, they are identical to NT2 but are too small to be delineated at a map scale of 1:50,000. Wet segments of the Peyto Lake 5 (PL5) Ecosite often resemble SX3. However, PL5 has a compound dry > wet landscape pattern on moraines dominated by calcareous, medium textured till (Till C) which differentiates it from the dominantly wet landscape pattern associated with SX3. The SX1 and SX2 Ecosites are differentiated from SX3 by vegetational differences as outlined in Table 339.

TA - TALBOT ECOSECTION

The Talbot (TA) Ecosection consists of surficial veneers of calcareous, medium textured eolian material (Eolian material A) overlying morainal deposits. Regosolic or a pattern of Regosolic and Brunisolic soils typify TA. Vegetation cover is dominated by moist white spruce forest, grassland, and low shrub-herb meadow.

This Ecosection occurs in the Montane Ecoregion in Banff and Jasper. In Banff, TA occurs on the lower slopes of the Howse and North Saskatchewan River valleys near their confluence. In Jasper, TA occurs on the lower slopes of the Athabasca River valley from just south of Jacques Creek to Jasper's east gate.

Two Ecosites (TA2, TA3) are recognized within the TA Ecosection These Ecosites are separated primarily on vegetational differences with minor differences in soils and underlying parent materials. Table 346 outlines the general features of the TA Ecosites.

TA2 - TALBOT 2 ECOSITE

Ecosite Concept

The TA2 Ecosite is characterized by veneers of calcareous, medium textured eolian material (Eolian material A) overlying morainal veneers of calcareous, medium textured till (Till C) over inclined bedrock. The TA2 Ecosite is dominated by rapidly to well drained Orthic and Cumulic Regosols associated with the junegrass-pasture sage-wild blue flax (H6) and shrubby cinquefoil/bearberry-northern bedstraw (L1) v.t.s. The TA2 Ecosite is mapped only in the Montane Ecoregion of Jasper. It occurs between the south end of Jasper Lake and Jasper's east gate in the Athabasca River valley. A typical TA2 landscape near Moosehorn Creek is shown in Plate 167.

Geomorphology

The TA2 Ecosite is characterized by veneers of calcareous, medium textured eolian material (Eolian material A) overlying morainal veneers of calcareous, medium textured till (Till C) over inclined bedrock. The postglacial eolian deposits are produced when periodic strong winds disseminate calcareous material from the floodplain of the Athabasca River and shores of Jasper Lake. Extremely calcareous soils are a result of this ongoing activity. The TA2 Ecosite is most commonly found as erosional scarps, formed by the Athabasca River, that are being subsequently mantled by eolian deposits. Eolian blankets occur in pockets protected from active erosion. Minor amounts of calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) occur on the lower slopes of erosional scarps adjacent to the Athabasca River. Slopes between 30 and 70% characterize TA2. Many of these slopes are linear but despite this, tracts may be designated as complex because of the effects of bedrock control. A few tracts of TA2 have eolian veneers overlying bedrock and are designated as TA2X. Bedrock outcrops dominate those tracts mapped as TA2+R.

Soils

The TA2 Ecosite is dominated by rapidly to

Table 346 General features of the Talbot (TA) Ecosites.

Ecosite	Landform	Soils	Vegetation
TA2	Eolian material A; veneer	Regosolic	grassland, low shrub-herb meadow
TA3	Eolian material A; veneer	Regosolic > Brunisolic	white spruce forest

Table 347 Pedon (Alberta 1979 No. 64) description of an Orthic Regosol of the TA2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC REGOSOL. SOIL MAP UNIT: NOTATION: TA2.

LOCATION: MILITARY GRID REF. 11 UNJ 3235 0670; NTS MAP AREA 83E 1E.

CLIMATE: 1140 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS MODERATE RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 13 DEG(C) AT 20 CM IN MAY.

VEGETATION: VPN=BJ9001*VTH=H6*.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), EOLIAN; LANDFORM CLASSIFICATION: EOLIAN, VENEER; SLOPE: 32% SIMPLE SLOPE OF CLASS 7 (31-45%), FACING SOUTHEAST, SITE AT UPPER SLOPE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,200 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, SEEPAGE ABSENT; NONSTONY; NONROCKY.

SPECIAL NOTES: SBN=MT9001*APH=015-151*RLU=15*PCF=16R(S)*LFH=EV/MI*TOP 12CM ARE WEAKLY TURFY BECAUSE OF ABUNDANT ROOTS*

CK1: 0 TO 64 CM, RANGE 62 TO 66 CM; HORIZON DRY AND MOIST; MATRIX MOIST 10YR 5/3, MATRIX DRY 2.5Y 6/2; SILT; STRUCTURELESS, MASSIVE STRUCTURE PSEUDO; VERY FRIABLE CONSISTENCE; FEW, MICRO AND VERY FINE AND FINE AND MEDIUM, VERTICAL ROOTS; HIGHLY POROUS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CK2: 64 TO 77 CM, RANGE 12 TO 16 CM; HORIZON MOIST; MATRIX MOIST 10YR 4/3; SILT; STRUCTURELESS, MASSIVE STRUCTURE PSEUDO; VERY FRIABLE CONSISTENCE; FEW, MICRO AND VERY FINE AND FINE, VERTICAL ROOTS; HIGHLY POROUS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CK3: 77 TO 103 CM, RANGE 23 TO 30 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/4; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE PSEUDO; VERY FRIABLE CONSISTENCE; VERY FEW, MICRO AND VERY FINE AND FINE, VERTICAL ROOTS; HIGHLY POROUS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, GRADUAL HORIZON BOUNDARY.

2CK1: 103 TO 165 CM, RANGE 55 TO 65 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/3; LOAM; STRUCTURELESS, MASSIVE STRUCTURE PSEUDO; VERY FRIABLE CONSISTENCE; VERY FEW AND FEW AND PLENTIFUL, MICRO AND VERY FINE AND FINE, VERTICAL AND RANDOM ROOTS; HIGHLY POROUS; STRONG EFFERVESCENCE; STRONGLY CALCAREOUS; WAVY, GRADUAL HORIZON BOUNDARY.

2CK2: 165 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/3; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE PSEUDO; VERY FRIABLE CONSISTENCE; HIGHLY POROUS; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; 10% GRAVELLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	CALC CARB EQU.%
CK1	7.5	54.2
CK2	7.6	51.7
CK3	8.1	44.0
2CK1	8.3	23.1
2CK2	8.4	27.4

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
CK1								2	5	7		85	8	
CK2	99	99	99	99			1	3	7	11		81	8	
CK3						1	1	3	7	12		79	9	
2CK1	99	99	99	98		1	5	22	22	50		42	8	
2CK2	99	99	95	93	1	2	5	15	17	40		50	10	

PHYSICAL DATA

ENGINEERING

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
CK1							A0	10
CK2								
CK3								
2CK1	35.0	37.0					A0	09
2CK2	22.0	26.0					A0	19

well drained, extremely calcareous Orthic and Cumulic Regosols. These soils are the result of active deposition of wind blown material. Orthic Eutric Brunisols occur in minor amounts on local areas that are protected from any significant addition of wind blown material. Tracts mapped as TA2 are located at some distance from source areas and thus, the eolian material is primarily uniformly medium textured and free of coarse fragments. A pedon illustrating Orthic Regosols of TA2 is described in Table 347 and shown im Color Plate 73. This pedon was sampled on a southeast facing slope above Jasper Laike in Jasper.

Vegetation

The TA2 Ecosite is dominated by the junegrass-pasture sage-wild blue flax (H6) and shrubby cinquefoil/bearberry-northern bedstraw (L1) v.t.s. The majority of H6 on TA2 occurs on the southerly and easterly facing erosional scarps above the Athabasca River between Jasper Lake and Jasper's east gate. The L1 v.t. on TA2 is commonly found on steep southerly exposures. White spruce/juniper/bearberry (O17) is an accessory v.t. commonly found in gullies dissecting erosional scarps and on northerly aspects. A few tracts of TA2 are dominated by O17. A

plot illustrating the H6 v.t. on TA2 is described in Table 348 and shown in Plate 168 and represents the vegetation at the pedon sample site described above in Table 347.

Table 348 Stand (SJ9001) illustrating the junegrass-pasture sage-wild blue flax (H6) v.t. of the TA2 Ecosite.

	HERB-DWARF SHRUB LAYER
Agropyron dasystachyum	12
Antennaria nitida	.5
Artemisia frigida	12
Artemisia michauxiana	.5
Carex eburnea	.5
Commandra pallida	07
Gaillardia aristata	01
Galium boreale	.5
Koeleria cristata	20
Linum lewisii	05
Lithospermum incisum	.5
Senecio cymbalarioides	03
Stipa comata	.5
	BRYOID LAYER
Barbula icmadophila	01

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The TA2 Ecosite may resemble the southerly portion of Norquay 3 (NY3) where v.t.s H6 and L1 appear on similar landscapes. However, NY3 is not characterized by surficial veneers of calcareous, medium textured eolian material (Eolian material A). The TA2 Ecosite may appear similar to some tracts of Devona 1 (DV1) where they both support the H6 v.t. They differ in that DV1 is restricted to a dune landscape exhibiting much deeper eolian deposits.

TA3 - TALBOT 3 ECOSITE

Ecosite Concept

The Montane Ecosite, TA3, is characterized by veneers of calcareous, medium textured eolian material (Eolian material A) overlying glacial landforms consisting of calcareous, medium textured till (Till C) and calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). Landform surface expression, dominantly ridged or hummocky, is controlled by the underlying glacial drift or bedrock. A soil pattern in which Cumulic Regosols are dominant and Orthic Eutric Brunisols are subdominant typifies the soil component of TA3. The white spruce/buffaloberry/fern moss (C26), white spruce/fern moss (C2), and white spruce/prickly rose/fern moss (C27) v.t.s typify the vegetation component.

Geomorphology

The TA3 Ecosite is characterized by veneers of calcareous, medium textured eolian material (Eolian material A) overlying glacial landforms consisting of calcareous, medium textured till (Till C) and calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B). Landform surface expression is controlled by the underlying glacial drift or bedrock. Thicker deposits result in eolian blanket landforms that occur in minor amounts close to the loessal source. Surficial veneers decrease in thickness downwind from the source and upslope from the valley bottom. Active deposition of eolian material is reflected by soils without distinct horizons. Slopes range from 5 to 70% and are often complex.

Soils

The TA3 Ecosite is dominated by a pattern of well drained, extremely calcareous Cumulic Regosols and Orthic Eutric Brunisols. Cumulic Regosols are more abundant and reflect periods of active deposition interspersed with periods of non-deposition. Orthic Eutric Brunisols are less common and usually occur on portions of the landscape furthest from source areas. Orthic Regosols are accessory soils that occur on steep eroded escarpments and close to source areas where active deposition is more frequent. A pedon illustrating Cumulic Regosols of TA3 is described in Table 349. This pedon has "buried" Bmk horizons indicative of periods of active deposition interspersed with periods of non-deposition. This pedon was sampled above Talbot Lake in Jasper. Color Plate 74 shows a similar pedon (Cumulic Regosol) described in the North Saskatchewan River valley in Banff.

Vegetation

The TA3 Ecosite is dominated by the mesic v.t.s white spruce/buffaloberry/fern moss (C26), white spruce/fern moss (C2), and white spruce/prickly rose/fern moss (C27). The C26 v.t. is most abundant on tracts of TA3 in Jasper and in the North Saskatchewan River valley in Banff. Some tracts of TA3 are dominated by the C2 and C27 v.t.s and only occur in Jasper. The calciphile *Thuidium abietinum* is the predominant moss in the understory of the above v.t.s and reflects the presence of carbonates at the surface. Minor amounts of the white spruce/shrubby cinquefoil/bearberry (O3), white spruce/juniper/bearberry (O17), paper birch/bearberry (O16) and shrubby cinquefoil/bearberry-northern bedstraw (L1) v.t.s occur on exposed slopes. Tracts of TA3 affected by fire have small amounts of lodgepole pine/juniper/bearberry (C3), lodgepole pine/buffaloberry/showy aster (C6) and lodgepole pine/buffaloberry/twinflower (C19). The Engelmann spruce-subalpine fir/feathermoss (C13)

Table 349 Pedon (Alberta 1977 No. 117) description of a Cumulic Regosol of the TA3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: CUMULIC REGOSOL. SOIL MAP UNIT: NOTATION: TA3.

LOCATION: MILITARY GRID REF. 11 UMJ 3590 8545; NTS MAP AREA 83F 4W.

CLIMATE: 1140 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS MODERATE RELEVANCE TO THE SOIL SITE.

VEGETATION: VPN=JC7095=VTN=C27=.

SOIL SITE: PARENT MATERIAL 1: COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6 % CACO3), EOLIAN; PARENT MATERIAL 2: COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), MORAINAL (TILL); LANDFORM CLASSIFICATION: EOLIAN, VENEER; SLOPE: 3% SIMPLE SLOPE OF CLASS 3 (2-5%), FACING SOUTHWEST AND WEST, SITE AT MIDDLE POSITION; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; NONSTONY; NONROCKY.

SPECIAL NOTES: SSN=DA7140=APN=015-150=PCF=

LF: 6 TO 0 CM, RANGE 4 TO 10 CM; ABUNDANT, FINE AND MEDIUM AND COARSE, HORIZONTAL ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK1: 0 TO 12 CM, RANGE 10 TO 13 CM; MATRIX MOIST 10YR 4/3; SILT LOAM; STRUCTURELESS STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM, OBLIQUE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

BMBK1: 12 TO 22 CM, RANGE 9 TO 12 CM; MATRIX MOIST 7.5YR 4/4; SILT LOAM; STRUCTURELESS STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE AND MEDIUM, OBLIQUE ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, CLOSED, VESICULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CK2: 22 TO 48 CM, RANGE 22 TO 31 CM; MATRIX MOIST 10YR 4/2; SILT LOAM; STRUCTURELESS STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE AND FINE, OBLIQUE ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, CLOSED, VESICULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CK3: 48 TO 53 CM, RANGE 0 TO 5 CM; MATRIX MOIST 10YR 5/3; SILT LOAM; STRUCTURELESS STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, FINE, OBLIQUE ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, CLOSED, VESICULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; BROKEN, DIFFUSE HORIZON BOUNDARY.

CK4: 53 TO 65 CM, RANGE 12 TO 15 CM; MATRIX MOIST 7.5YR 4/4; SILT LOAM; VERY FRIABLE CONSISTENCE; VERY FEW, FINE, OBLIQUE ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, CLOSED, VESICULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CK5: 65 TO 74 CM, RANGE 7 TO 10 CM; MATRIX MOIST 10YR 5/4; SILT LOAM; STRUCTURELESS STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, VERY FINE AND FINE, OBLIQUE ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, CLOSED, VESICULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

BMBK2: 74 TO 101 CM, RANGE 25 TO 30 CM; MATRIX MOIST 7.5YR 5/6; SILT LOAM; STRUCTURELESS STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, VERY FINE AND FINE, OBLIQUE ROOTS; COMMON, FINE, RANDOM, CONTINUOUS, CLOSED, VESICULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

2CK1: 101 TO 117 CM, RANGE 12 TO 16 CM; MATRIX MOIST 10YR 5/4; SILT LOAM; STRUCTURELESS STRUCTURE; VERY FRIABLE CONSISTENCE; COMMON, FINE, RANDOM, CONTINUOUS, CLOSED, VESICULAR PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; GRAVELLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

2CK2: 117 TO 125 CM; MATRIX MOIST 10YR 6/3; SANDY LOAM; STRUCTURELESS STRUCTURE; SINGLE GRAIN SECONDARY STRUCTURE; LOOSE CONSISTENCE; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; GRAVELLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LF			
CK1	7.6		32.8
BMBK1	7.8		41.3
CK2	8.0	2.60	46.0
CK3	8.0		21.3
CK4	8.0	2.90	41.3
CK5	8.1		32.8
BMBK2	8.3		23.0
2CK1	8.2		27.7
2CK2	8.2		32.8

PHYSICAL DATA (SURVEY)

	% PASSING				PARTICLE SIZE ANALYSIS						% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
CK1					0	0	1	4	9	14		72	14	
BMBK1					0	0	2	6	11	19		67	14	4
CK2					0	0	1	3	7	11		71	18	5
CK3					0	0	1	4	12	17		72	11	3
CK4					0	0	0	2	7	9		71	20	4
CK5					0	1	2	4	9	16		68	16	4
BMBK2					0	1	3	5	12	21		63	16	3
2CK1					1	2	4	10	17	34		53	13	3
2CK2		99	54	37	34	3	7	19	19	11	59	31	10	2

PHYSICAL DATA

	ENGINEERING							
HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
CK1								
BMBK1								
CK2								
CK3								
CK4								
CK5								
BMBK2								
2CK1	20.0	24.0		10.0	1.7		40	19
2CK2	0.0	0.0					12	03

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
CK1				
BMBK1	0.2		-.1	
CK2				
CK3				
CK4				
CK5				
BMBK2				
2CK1				
2CK2				

v.t. occurs in minor amounts in the North Saskatchewan River valley in Banff. In Jasper, minor amounts of the aspen/hairy wild rye-peavine (C16) and balsam poplar/buffaloberry (C17) v.t.s occur on a tract of TA3 between Mountain Creek and the Fiddle River. The vegetation plot description in Table 350 illustrates the C27 v.t. on TA3 and represents the vegetation at the pedon sample site described in Table 349. Plate 169 shows the vegetation at this site.

Table 350 Stand (JC7095) illustrating the white spruce/prickly rose/fern moss (C27) v.t. of the TA3 Ecosite.

TREE LAYER	
Picea glauca	34
Pinus contorta	08
TALL SHRUB LAYER	
Picea glauca	.5
SHRUB LAYER	
Juniperus communis	02
Lonicera dioica	.5
Picea glauca	.5
Rosa acicularis	05
Shepherdia canadensis	01
HERB-DWARF SHRUB LAYER	
Arctostaphylos uva-ursi	05
Aster ciliolatus	.5
Carex concinna	01
Corralorhiza trifida	.5
Elymus innovatus	25
Geocaulon lividum	02
Habenaria obtusata	.5
Hedysarum sulphurescens	.5
Linnaea borealis	40
Pyrola asarifolia	.5
Pyrola secunda	02
BRYOID LAYER	
Dicranum spp.	02
Ditrichum flexicaule	.5
Eurhynchium pulchellum	.5
Hylocomium splendens	20
Hypnum revolutum	.5
Peltigera malacea	02
Pylaisiella polyantha	.5
Thuidium abietinum	60
Tortula ruralis	01

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

Vegetational differences are the main criteria for separating TA3 from TA2 as outlined in Table 346. The TA3 Ecosite resembles the Devona 2 (DV2) Ecosite in that the deposits are eolian and associated with the white spruce/prickly rose/fern moss (C27)v.t. However, DV2 has much deeper eolian deposits with surface expression that does not conform to underlying materials. Trees on tracts of TA3 in the North Saskatchewan River valley in Banff are susceptible to blowdown.

TK - TEKARRA ECOSECTION

The Tekarra (TK) Ecosection encompasses steep, usually linear, colluvial landforms comprised of noncalcareous, coarse textured colluvium (Colluvium A) in the Alpine Ecoregion of Banff and Jasper. It occurs predominantly in the Main Ranges on or below steep, rocky walls in areas that are geologically dominated by Cambrian Gog Group quartzites.

Dystric and Sombric Brunisols and Regosols characterize the soil component of TK. These well drained soils reflect the acidic, coarse textured parent material. The vegetation component is characterized by heath and mountain avens tundra. Only one Ecosite (TK1) is recognized within the TK Ecosection. Its general features are outlined in Table 351. Fig. 40, for the Endless Chain Ecosection, shows schematically the physiographic position of TK1 in relation to other Ecosites.

TK1 - TEKARRA 1 ECOSITE

Ecosite Concept

The Alpine Ecosite, TK1, encompasses blankets and veneers consisting of noncalcareous, coarse textured colluvium (Colluvium A) overlying inclined bedrock on steep valley walls. Colluviation including soil creep and avalanching occurs locally. Orthic Dystric Brunisols, Orthic Sombric Brunisols, and Orthic Regosols are the dominant soils. Vegetation is dominated by the heather-everlasting (L5) and mountain avens-snow willow-moss campion (H1) v.t.s.

Geomorphology

The TK1 Ecosite occurs on blankets and veneers comprised of noncalcareous, coarse textured colluvium (Colluvium A) overlying inclined bedrock on steep valley walls. Underlying bedrock is predominantly Gog Group quartzites. Colluviation, including soil creep

Table 351 General features of the Tekarra 1 (TK1) Ecosite.

Ecosite	Landform	Soils	Vegetation
TK1	Colluvium A; blanket, veneer	Dystric Brunisol, Sombric Brunisol, Regosol	heath tundra, mountain avens tundra

and avalanching, occurs locally. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically and are most abundant on TK1 tracts of western Banff and southwestern Jasper. Erosional and colluvial processes have removed or incorporated most of the eolian materials. Rubble without fine earth material for soil development is common on some TK1 tracts, particularly those occurring below steep rock walls.

Topographically, TK1 displays long, linear, inclined slopes commonly ranging from 45 to >100%. Tracts mapped as TK1 with complex topography have linear slopes whose continuity is broken by one or more exceptionally steep bedrock escarpments. On those tracts mapped as TK1X, colluvial veneers are dominant. Exposed bedrock dominates on TK1+R tracts. Tracts with failed slopes (TK1F), including failure of unconsolidated material and partial failure of underlying bedrock, occur occasionally.

Soils

Soil development and distribution is reflected by the degree and intensity of surface colluviation and, to a lesser extent, avalanching. Orthic Dystric Brunisols, Orthic Sombric Brunisols, and Orthic Regosols are the dominant soils. Orthic Dystric Brunisols occupy localities where accumulation of organic matter is small and eluvial (Ae) horizon development is inhibited or has been destroyed. Orthic Sombric Brunisols occupy localities where humus accumulation in the upper sola is evident. Locally, colluviation has physically thickened surface organo-mineral (Ah) horizons. Orthic Regosols occupy localities where geomorphic activity is frequent and intense, such as unvegetated rubbly sites.

Soils of the TK1 Ecosite are well drained and reflect in their development, the acidic, coarse textured parent material. The Brunisolic soils have thick sola and strongly developed B horizons. The Orthic Dystric Brunisols and Orthic Regosols may or may not have thin Ah horizons. The accessory Eluviated Dystric Brunisols have well developed eluvial (Ae) horizons. Orthic Humo-Ferric Podzols occur occasionally and are associated with the veneers of altered, medium textured eolian material (Eolian material B) on stable sites. Lithic soil phases dominate on those tracts mapped as TK1X. A pedon illustrating Orthic Dystric Brunisols of TK1 is described in Table 352 and shown in Color Plate 75. This pedon was sampled on the south slope of Eiffel Peak in Banff.

Vegetation

Distribution of vegetation on the TK1 Ecosite reflects the degree of colluvial activity, exposure, and elevation. The heather-everlasting (L5) and mountain avens-snow willow-moss campion (H1) v.t.s are dominant. Within the Alpine Ecoregion, H1 generally occurs at higher elevations than L5. Up to 15% krumholz and tree islands are included with L5 along lower boundaries of some TK1 tracts. White mountain heather-mountain avens-snow willow (L4) is an accessory v.t. that occurs in late snow lie areas. The mountain avens-kobresia-bearberry (H4) and saxicolous lichen (H12) v.t.s occur in minor amounts. Unvegetated portions, associated with rubbly colluvium and Regosolic soils on sites that are geomorphically intansely active, may constitute up to 50% of TK1 tracts, or up to 80% of TK1+T or TK1+CR tracts. A plot illustrating the H1 v.t. of TK1 is described in Table 353 and shown in Plate 170 and represents vegetation at the pedon sample site described above in Table 352.

Table 353 Stand (JC8092) illustrating the mountain avens-snow willow-moss campion (H1) v.t. of the TK1 Ecosite.

	HERB-DWARF SHRUB LAYER
Astragalus alpinus	01
Carex media	01
Carex nardina	07
Cerastium spp.	.5
Dryas octopetala	45
Festuca brachyphylla	03
Luzula spicata	.5
Phyllodoce glanduliflora	.5
Poa spp.	02
Potentilla nivea	01
Salix nivalis	.5
Saxifraga bronchialis	01
Silene acaulis	01
Solidago multiradiata	.5
Trisetum spicatum	01
Selaginella densa	01
	BRYOID LAYER
Bryoerythrophyllum recurvirostrum	.5
Buellia papillata	.5
Cladonia squamosa	.5
Encalypta rhaptocarpa	.5
Hypnum revolutum	.5
Tortula ruralis	02

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

In terms of landform surface expression, physiographic position, and vegetation cover, TK1 resembles the Bow Summit (BS1) and Redoubt 1 (RD1) Ecosites. However, in contrast to the Colluvium A of TK1, BS1 occurs on colluvial landforms consisting of calcareous, medium textured colluvium (Colluvium C), and RD1 occcurs on noncalcareous, medium textured colluvium (Colluvium B).

Table 352 Pedon (Alberta 1978 No. 78) description of an Orthic Dystric Brunisol of the TK1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: TK1.

LOCATION: MILITARY GRID REF. 11 UNG 8610 5360; NTS MAP AREA 82N 8E.

CLIMATE: 2560 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VPN=JC8092=VTH=H1=.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EOLIAN; PARENT MATERIAL 2: MODERATE CHEMICAL WEATHERING, SANDY, MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), COLLUVIAL, QUARTZITE; LANDFORM CLASSIFICATION: COLLUVIAL, INCLINED; SLOPE: 60% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING SOUTH, SITE AT MIDDLE POSITION, MODERATELY MOUNDED MICROTOPOGRAPHY,250 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, RAPIDLY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; EXCEEDINGLY STONY; SLIGHTLY ROCKY.

SPECIAL NOTES: SSM=MT6157=APM=703-61=R U=15=PCF=2AGR,1ACB(2)3AGR,2ACB(3)3AGR,3ACB,2ST(4)4AGR,4ACB,3ST(5)=

L: -2 TO 0 CM, RANGE 0 TO 3 CM; HORIZON MOIST; MATRIX MOIST ; FEW, COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AH: 0 TO 7 CM, RANGE 6 TO 9 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/1; SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; WEAK, VERY FINE, GRANULAR SECONDARY STRUCTURE; FRIABLE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BM: 7 TO 28 CM, RANGE 18 TO 23 CM; HORIZON MOIST; MATRIX MOIST 5YR 3/3; SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

2BM: 28 TO 60 CM, RANGE 25 TO 35 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/5; SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; IRREGULAR, CLEAR HORIZON BOUNDARY; VERY STRONGLY ACID 4.6-5.0 FIELD PH.

2BC: 60 TO 112 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/5; GRAVELLY LOAMY SAND; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; FEW, MICRO AND VERY FINE AND FINE ROOTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
L	5.4	36.20						
AH	5.2	6.50	16.7		13.4	1.3	0.1	0.3
BM	4.7	3.10	8.2		1.9	0.5	-.1	0.1
2BM	4.8	1.30	4.1		0.9	0.2	-.1	-.1
2BC	6.5		1.7		3.2	0.2	-.1	-.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
L				
AH				
BM	0.2		0.2	
2BM	0.2		0.1	
2BC				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	% OF SAMPLE 50-2U SILT	% OF SAMPLE 2U CLAY	% OF SAMPLE 0.2U CLAY
L														
AH					5	16	26	14	4	65		26	9	
BM					10	14	24	17	4	69		27	4	
2BM					5	14	27	29	4	78		28	2	
2BC	99	49	8	3	9	17	34	21	4	85		15	8	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOISY	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	ENGINEERING SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
L													
AH		28.9	22.4										
BM													
2BM													
2BC		6.6	2.1									11	02

Also, BS1 has neutral to alkaline soils and RD1 has soils similar to TK1 but the sola are thinner. Regosolic soils are more extensive on BS1 and RD1 than on TK1. The Endless Chain Ecosites are the Upper Subalpine counterparts to TK1.

TR - TYRRELL ECOSECTION

The Tyrrell Ecosection encompasses dry to moist, shrubland and grassland dominated, morainal landforms in the Upper Subalpine portion of the Subalpine Ecoregion in Banff and Jasper. The moraines consist of calcareous, medium textured till (Till C), less often noncalcareous, medium textured till (Till B), and weakly calcareous materials intergradient between the two. The TR Ecosection occupies valley floor benchlands, valley walls, shoulders, cirque basins, and cols and is most extensive in the Front Ranges in association with Mesozoic and adjacent strata. Fig. 53

shows, schematically, the positions of TR1 and TR2 relative to some other Ecosites.

The vegetation of TR readily distinguishes it from other dry Upper Subalpine morainal Ecosections. Various climatic and lithologic differences, in combination, may be the factors contributing to this vegetation dissimilarity. Vegetation differentiates the two Tyrrell Ecosites (Table 354), the contrast reflecting primarily aspect and exposure. The TR1 Ecosite is shrub dominated with dry shrub thicket, moist shrub thicket and Engelmann spruce-subalpine fir forest. The more exposed, southerly aspect slopes of TR2 are characterized by grassy tundra and dry grassland. Upper Subalpine shrub and herb vegetation and the concomitant organic matter rich Ah horizons result in Eutric and Melanic Brunisols which characterize the soils of the TR Ecosction (Table 354).

TR1 - TYRRELL 1 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, TR1, occurs on morainal blankets and veneers overlying inclined, hummocky, and ridged bedrock. The moraines consist most often of calcareous, medium textured till (Till C), less often of noncalcareous, medium textured till (Till B), and weakly calcareous materials intergradient between the two. Soils of the TR1 Ecosite occur in a pattern reflecting the amount of humus incorporation and the degree of eluviation. Orthic Eutric Brunisols are dominant, Eluviated Eutric Brunisols and Orthic Melanic Brunisols are subdominant. Vegetationally, TR1 is very complex with dry to moist (mesic) shrubby v.t.s, best represented by willow-dwarf birch-shrubby cinquefoil (S10) and willow/hairy wild rye (S12) (Plate 171). The Engelmann spruce-subalpine fir/willow/hairy wild rye (O18) v.t. is common locally and dominates a few TR1 tracts. Several other v.t.s have a high frequency but low areal extent on TR1.

The TR1 Ecosite occurs on valley bottom benchlands, valley walls, shoulders, and in cirque basins and cols. It is most extensive in eastern Banff and Jasper in the upper reaches of compound valleys underlain by Mesozoic strata (e.g. Tyrrell Creek valley and its tributaries in Banff). The TR1 Ecosite also occurs sporadically in simple valley systems in the Main Ranges (e.g. upper Baker Creek valley, upper Siffleur River valley and Nigel Pass in Banff, and Wilcox Pass in Jasper).

Geomorphology

The TR1 Ecosite is typified by morainal landforms consisting primarily of calcareous, medium textured till (Till C). A few tracts are dominated by noncalcareous, medium textured till (Till B) derived from noncalcareous Mesozoic strata. Weakly calcareous materials intergradient between the two tills commonly occur. Thin fluvial deposits, usually calcareous, coarse, stratified fluvial material (Fluvial material B), occur locally on TR1 tracts located on or near valley and cirque floors and cols. These are associated with intermittent and permanent streams. Veneers of altered, medium textured eolian material (Eolian material B) occur sporadically and are generally thin and mixed with small amounts of till. Colluvium derived from till and fractured bedrock occurs occasionally on the steepest portions of the landscape.

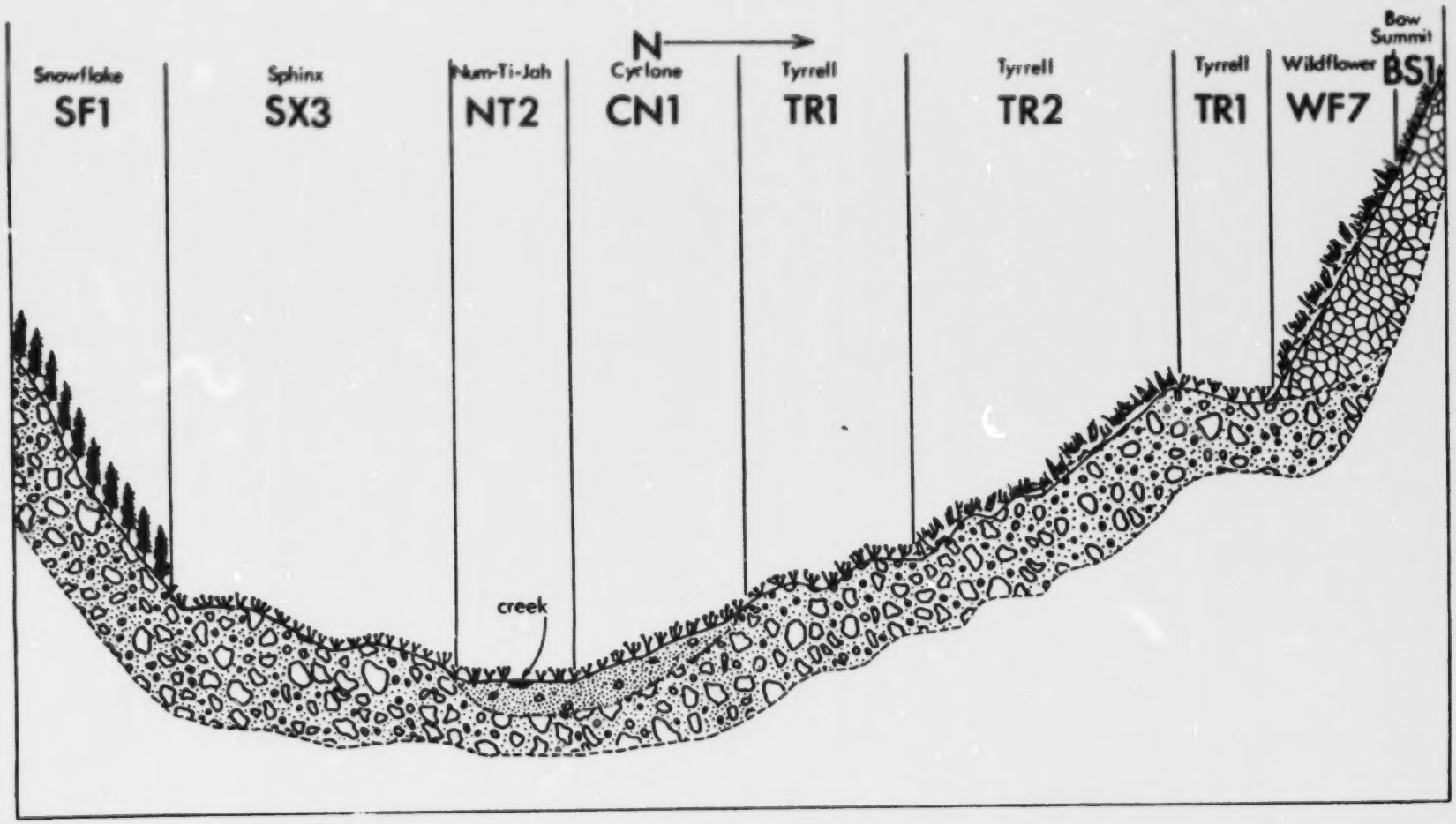
Topographically, TR1 displays linear slopes on valley walls and the irregular topography of hummocky and ridged slopes on valley floor benchlands, shoulders, cirque basins, and cols. Surface expression normally reflects underlying bedrock although deep till deposits, with a depositional hummocky surface form, occur occasionally on valley floor positions and on failed slopes. Slopes commonly range from 5 to 45%. Slopes steeper than 45% dominate a few TR1 tracts. Tracts on floor and lower slope positions often display, as part of their complex topography, cut and fill features associated with intermittent and permanent streams. These fluvial sites are occasionally affected by seepage and high water tables. Wet terrain normally accounts for 5 to 15% of TR1 but, on a few tracts, may be as high as 30%. Linear slopes are also often gullied.

Morainal veneers are common on hummock and ridge crests and dominate tracts mapped as TR1X. Bedrock outcrops occur sporadically but are abundant on TR1+R tracts. Col-

Table 354 General features of the Tyrrell (TR) Ecosites.

Ecosite	Landform	Soils	Vegetation
TR1	Till B,C; blanket, veneer	Eutric Brunisol > Melanic Brunisol	dry and moist shrub thicket, Engelmann spruce-subalpine fir open forest
TR2	Till B,C; blanket	Eutric Brunisol, Melanic Brunisol	grassy tundra, dry grassland

Figure 53 Landscape schematic showing the relationship of the Tyrrell (TR) Ecosites to other Ecosites.



luvial blankets and veneers occur locally on the steepest terrain, particularly below bedrock escarpments.

Soils

A soil pattern reflecting the degree of eluviation versus the amount of humus incorporation in upper sola characterizes the TR1 Ecosite. Orthic Eutric Brunisols are dominant, Eluviated Eutric Brunisols and Orthic Melanic Brunisols are subdominant. Under the near Alpine environment with shrub dominated vegetation, humus accumulation in the upper sola of these well to moderately well drained soils is evident, often masking the effects of eluviation. Thus, TR1 soils have varying thicknesses of Ah and/or Ahe horizons. Most TR1 soils have neutral sola with high base saturation. Consequently, TR1 soils display a narrow range of pH from surface to C horizons. Eluvial (Ae) horizons are weakly expressed and discontinuous across the landscape. The TR1 soils have weakly to moderately developed Bm horizons that occasionally have more clay than the horizon above or below, a characteristic associated with weathering of calcareous parent material. The Brunisolic soils sometimes have Bf and Bhf horizons above the parent material disconform-

Table 355 Pedon (Alberta 1979 No. 53) description of an Orthic Eutric Brunisol of the TR1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: TR1.

LOCATION: MILITARY GRID REF. 11 UMJ 9150 4000; NTS MAP AREA 83C 11*.

CLIMATE: 2140 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 9 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: VPN=PA9115*VTN=S10*.

SOIL SITE: PARENT MATERIAL 1: CHEMICAL AND PHYSICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL), SHALE AND SANDSTONE AND LIMESTONE; LANDFORM CLASSIFICATION: MORAINAL, GRAVELLY AND LOAMY, BLANKET; SLOPE: 28% SIMPLE SLOPE OF CLASS 6 (16-30%), FACING SOUTH, SITE AT LOWER SLOPE POSITION, SLIGHTLY ROUNDED MICROTOPOGRAPHY,500 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT, SLIGHT WATER EROSION; SLIGHTLY STONY; NONROCKY; HUMUS-FORM: MULL AND FINE, LOAMY, NEUTRAL.

SPECIAL NOTES: SSN=PS9163*APN=010-017*PCF=3AG(1)3AG,2FL(2-3)3AGR(4)*LFH=MB/RI*DATE=AUG.24,1979*

AH: 0 TO 5 CM, RANGE 4 TO 9 CM; HORIZON MOIST; CRUSHED MOIST 10YR 2/1; SILT LOAM; WEAK, FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MEDIUM AND VERY FINE AND FINE, RANDOM, INPED AND EXPED ROOTS; HIGHLY POROUS; 20% ANGULAR GRAVELLY COARSE FRAGMENTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

BM1: 5 TO 35 CM, RANGE 25 TO 35 CM; HORIZON MOIST; CRUSHED MOIST 10YR 3/4; SILT LOAM; WEAK TO MODERATE, FINE TO MEDIUM, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MEDIUM AND FINE, RANDOM, INPED AND EXPED ROOTS; HIGHLY POROUS; 30% ANGULAR GRAVELLY AND FLAGGY COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY; SLIGHTLY ACID 6.1-6.5 FIELD PH.

BM2: 35 TO 71 CM, RANGE 30 TO 40 CM; HORIZON MOIST; CRUSHED MOIST 7.5YR 4/4; SILT LOAM; WEAK TO MODERATE, FINE TO MEDIUM, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MEDIUM AND FINE, RANDOM, INPED AND EXPED ROOTS; HIGHLY POROUS; 30% ANGULAR GRAVELLY AND FLAGGY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

CK: 71 TO 109 CM; HORIZON MOIST; CRUSHED MOIST 10YR 4/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FINE, RANDOM ROOTS; MODERATELY POROUS; MODERATE EFFERVESCENCE; EXTREMELY CALCAREOUS; 20% ANGULAR GRAVELLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
AH	5.8	6.40		56.0		33.1	4.9	0.1	0.9
BM1	6.4	1.80		16.5		12.4	2.6	-.1	0.2
BM2	6.8	1.60	1.1						
CK	7.4		40.8						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
AH				
BM1	0.2		0.1	
BM2	0.2		-.1	
CK				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS % OF SAMPLE V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
AH						1	1	3	10	15		68	17		0.60
BM1					4	4	3	9	14	34		53	13		1.40
BM2					1	1	2	10	9	33		54	13		1.20
CK	99	96	84	81	10	9	4	8	8	39		53	8		1.80

PHYSICAL DATA

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AH								
BM1								
BM2								
CK	13.0	19.0		13.0	1.8		40	10

ity, particularly when they occur on cool, moist sites with veneers of altered, medium textured eolian material (Eolian material B) and white mountain heather-mountain avens-snow willow (L4) and heather-everlasting (L5) vegetation. Genetically related Podzolic soils, both Orthic Humo-Ferric Podzols and Orthic Ferro-Humic Podzols, occur rarely under the same conditions. Orthic Dystric and Orthic Sombric Brunisols occur in minor amounts on tracts or portions thereof comprised of noncalcareous, medium textured till (Till E). Various dry Regosolic soils, mainly Orthic Regosols and Orthic Humic Regosols, occur locally on colluviating and eroding sites. Various wet soils including gleyed Regosolic and Brunisolic soils and Gleysols are associated with seepage-affected depressional localities. Lithic soil phases are associated with morainal veneers dominant on tracts mapped as TR1X. Turbic phases of TR1 soils, produced by solifluction and cryoturbation, are common locally, particularly on moderately well to imperfectly drained, seepage affected sites. A pedon illustrating Orthic Eutric Brunisols of TR1 is described in Table 355 and shown in Color Plate 76.

Vegetation

Vegetation of the TR1 Ecosite is heterogeneous and complex. Dry to moist (mesic) shrubby v.t.s, best represented by willow-dwarf birch-shrubby cinquefoil (S10) and willow/hairy wild rye (S12), are most abundant. In many localities tree encroachment is occurring, represented by the Engelmann spruce-subalpine fir/willow/hairy wild rye (O18) v.t. A few tracts are dominated by O18. These three v.t.s, especially S10, are most extensive on southerly aspects. The S12 and O18 v.t.s occur occasionally on northerly aspects. In a few cases, shrubby vegetation (e.g. S12) presently dominates steep, northerly and easterly aspect, once forested slopes that were severely burned in recent times (e.g. the valley between Mt. Prow and Mt. White in Banff and Tyrell Creek valley in Banff shown in Plate 172). A plot representing vegetation of the pedon sample site described above (Table 355) and illustrating S10 on TR1 is presented in Table 356 and Plate 173.

Several accessory v.t.s are important to TR1 in that their frequency of occurrence is high but their areal extent is low. These v.t.s are mountain avens-snow willow-moss campion (H1), mountain avens-kobresia-bearberry (H4), white mountain heather-mountain avens-snow willow (L4), heather-everlasting (L5), willow/cinquefoil (S8), and Engelmann spruce-subalpine fir/heather (O10). The H1 and H4 v.t.s are common on exposed upper slopes and crests of hummocks and ridges. The H1 v.t. occurs most often on level to northerly facing slopes and on cryoturbated and soliflucted localities. Frequently, H4 occurs on southerly aspects in eastern Banff and Jasper. In eastern Banff and Jasper, L4 and in western to central Banff and Jasper, L5 characterize late snow lie localities on northerly aspects. Locally, S8 occurs on a variety of moist to wet (moderately well to poorly drained, subhygric to hygric) sites ranging from steep northerly aspects to gently sloping depressional localities. Episodic and seasonal seepage is usually associated with S8 and characterizes wet, dominantly fluvial, depressional terrain on TR1 tracts. The O10 v.t. occurs in small patches primarily on northerly aspects.

A variety of other v.t.s occur in minor amounts. Shrubby v.t.s occurring on moist to wet sites include willow-dwarf birch/fleabane (S4), dwarf birch-willow/kobresia (S9), and willow/timber oatgrass (S11). Arctic willow-cinquefoil (L7) also occurs on seepage affected sites. Forested patches on tract fringes and on northerly aspects include Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce/hairy wild rye (C33), and Engelmann spruce-subalpine fir/

Table 356 Stand (PA9115) illustrating the willow-dwarf birch-shrubby cinquefoil (S10) v.t. of the TR1 Ecosite.

SHRUB LAYER	
Salix glauca	50
HERB-DWARF SHRUB LAYER	
Achillea millefolium	01
Aconitum delphinifolium	.5
Agoseris glauca	.5
Antennaria lanata	.5
Arctostaphylos uva-ursi	10
Astragalus alpinus	01
Bromus pumpellianus	.5
Castilleja miniata	.5
Danthonia intermedia	02
Delphinium glaucum	.5
Elymus innovatus	30
Epilobium angustifolium	05
Erigeron peregrinus	02
Fragaria virginiana	05
Gentiana propinqua	01
Hedysarum alpinum	05
Juniperus communis	.5
Kobresia myosuroides	.5
Luzula spicata	.5
Pedicularis bracteosa	.5
Phleum alpinum	.5
Potentilla diversifolia	.5
Thalictrum occidentale	05
Trisetum spicatum	03
Botrychium lunaria	.5
BRYOID LAYER	
Brachythecium groenlandicum	05
Peltigera rufescens	10
Polytrichum juniperinum	05

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

heather/feathermoss (C34). Engelmann spruce-subalpine fir/valerian-fleabane (O9) occurs occasionally on soliflucted localities. Modification by avalanching (TR1A) occurs occasionally; severe recent burns (TR1B) rarely.

Discussion

In terms of landform and, in a broad sense, vegetation, TR1 resembles the Sphinx 3 (SX3) Ecosite. However, SX3 in contrast to the well and moderately well drained TR1, is confined to floors of valleys, cirques and cols and is dominated by seepage-affected, imperfectly to poorly drained soils displaying varying degrees of gleying. Also, the vegetation of SX3 is dominated by moist to wet, seepage-affected, shrubby v.t.s. Eutric and Melanic Brunisols of the Peyto Lake 4 (PL4) Ecosite are morphologically similar to TR1 soils, but usually have acidic rather than neutral upper sola with low rather than high base saturation. The TR2 Ecosite is distinguished from TR1 by its grassland vegetation reflecting a more exposed and steeply sloping, southerly aspect landscape (Table 354). There is no Lower Subalpine counterpart of TR1.

TR2 - TYRRELL 2 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, TR2, occurs on morainal blankets and veneers overlying inclined, hummocky, and ridged bedrock. The moraines consist most often of calcareous, medium textured till (Till C), less often of noncalcareous, medium textured till (Till B) and weakly calcareous mixtures intergradient between the two. Soils of the TR2 Ecosite, dominated by Orthic Eutric and Orthic Melanic Brunisols, reflect humus incorporation under grassland vegetation in the Upper Subalpine. Vegetation of TR2 is dominated by hairy wild rye-junegrass-bearberry (H14) and mountain avens-kobresia-bearberry (H4) reflecting exposure and southerly aspects.

The TR2 Ecosite occurs primarily on valley walls and on steeply sloping sections of shoulders, cirques, and cols, all with predominantly southerly aspects. It is most extensive in eastern Jasper and especially in eastern Banff, in the upper reaches of compound valleys underlain by Mesozoic strata (e.g. Divide Creek valley and its tributaries). Also, TR2 occurs sporadically in simple valley systems in the Main Ranges (e.g. upper Siffleur, Pipestone and Red Deer River valleys in Banff).

Geomorphology

The TR2 Ecosite is typified by morainal landforms consisting primarily of calcareous, medium textured till (Till C). A few tracts are dominated by noncalcareous, medium textured till (Till B) derived from noncalcareous Mesozoic strata. Weakly calcareous materials intergradient between the two tills commonly occur. Colluvium derived from till and fractured bedrock occurs occasionally on the steepest portions of the landscape. Veneers of altered, medium textured eolian material (Eolian material B) occur sporadically and are generally thin and include small amounts of till from below.

Topographically, TR2 displays linear slopes on valley walls and the irregular topography of hummocky and ridged slopes on shoulders, cirques, and cols. Surface expression normally reflects underlying bedrock although deep till deposits, with a depositional hummocky surface form, occur occasionally on lower slopes, and failed slopes. Ridged and hummocky surface expressions, whether reflecting bedrock or deposition, are generally superimposed on relatively steep inclines thereby limiting the areal extent of level to northerly-facing slopes (Fig. 53). A few exceptions to this kind of landscape occur in the Panther River and Dormer Creek drainages west of the Bare Mountains in Banff where a few TR2 tracts display a compound, forested versus nonforested landscape. Overall, TR2 slopes range from 30 to 70%, although over short distances slopes of 15 to 30% occur often. Some of the long linear slopes are dissected by gullies, and some of the steepest slopes have colluvial veneers and blankets overlying the till or bedrock.

Morainal veneers are common on hummock and ridge crests and dominate tracts mapped as TR2X. Bedrock outcrops occur sporadically but are abundant on the few TR2+R tracts.

Soils

Under the near Alpine conditions with subxeric to mesic grassland vegetation, humus accumulation in the upper sola of the rapidly to well drained TR2 soils is evident. Consequently, the Orthic Eutric Brunisols and Orthic Melanic Brunisols of TR2 have varying thicknesses of Ah horizons and little or no evidence of eluviation. They have weakly to moderately developed Bm horizons that occasionally have more clay than horizons above or below, a feature associated with weathering of calcareous parent material. Most TR2 soils have neutral upper sola with high base saturation and display a narrow range of pH from surface to C horizons. A pedon illustrating Orthic Eutric Brunisols of TR2 is described in Table 357 and shown in Color Plate 77.

Table 357 Pedon (Alberta 1978 No. 101) description of an Orthic Eutric Brunisol of the TR2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: TR2.

LOCATION: MILITARY GRID REF. 11 UNH 4670 3310; NTS MAP AREA 82H 9W.

CLIMATE: 2350 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VPN=PA8167#VTN=H044ISLANDS OF ES-AF#.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EOLIAN; PARENT MATERIAL 2: UNSPECIFIED WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL), LIMESTONE; LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 37% COMPLEX SLOPE OF CLASS 7 (31-45%), FACING SOUTH, SITE AT UPPER SLOPE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,100 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY.

SPECIAL NOTES: SSN=BW8148#APN=010-E08#RLU=15#SSC=MX#PCF=10R(2-3)4GR,2CB,3ST(4-6)#2BM IS A MIXTURE OF TILL + EOLIAN#

LF: 2 TO 0 CM, RANGE 1 TO 3 CM; MATRIX MOIST 10YR 2/2; ABUNDANT, VERY FINE AND FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AH: 0 TO 8 CM, RANGE 5 TO 11 CM; MATRIX MOIST 10YR 2/2; SILT LOAM; VERY WEAK, FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BM1: 8 TO 18 CM, RANGE 4 TO 14 CM; MATRIX MOIST 7.5YR 3/4, MATRIX MOIST 5YR 3/4; SILT LOAM; VERY WEAK, FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

2BM: 18 TO 24 CM, RANGE 0 TO 10 CM; MATRIX MOIST 7.5YR 5/6; GRAVELLY SILT LOAM; VERY WEAK, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE ROOTS; 50% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; BROKEN, CLEAR HORIZON BOUNDARY.

2BCK: 24 TO 39 CM, RANGE 4 TO 17 CM; MATRIX MOIST 7.5YR 4/4; GRAVELLY SILT LOAM; VERY WEAK, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO ROOTS; WEAK EFFERVESCENCE; WEAKLY CALCAREOUS; 50% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

2CK: 39 TO 90 CM; MATRIX MOIST 10YR 4.5/3; GRAVELLY SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY WEAK, FINE, SUBANGULAR BLOCKY SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, MICRO ROOTS; MANY, MICRO AND VERY FINE PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 50% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CAPB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	5.9	35.90							
AH	5.6	9.10		37.6		20.3	4.7	0.1	0.4
BM1	6.5	3.80	1.4						
2BM	7.2	1.60	8.8						
2BCK	7.4		32.6						
2CK	7.5		68.8						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AH				
BM1	0.1		0.1	
2BM	0.1		-.1	
2BCK				
2CK				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	% OF SAMPLE 50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF															
AH					2	3	4	6	9	24		60	16		
BM1					4	6	6	6	9	31		60	9		0.60
2BM					2	4	7	9	9	31		53	16		
2BCK					1	3	6	12	12	34		55	11		
2CK	99	69	51	41	12	12	11	12	7	54		42	4		1.80

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AH								
BM1								
2BM								
2BCK							12	07
2CK								

Orthic Dystric Brunisols, Orthic Regosols, and Orthic Humic Regosols are important accessory soils. Orthic Dystric Brunisols occur sporadically and are associated with occurrences of noncalcareous, medium textured till (Till B). They rarely occur under grassland vegetation but are more common under other v.t.e on northerly aspects or level localities. Orthic Regosols and Orthic Humic Regosols, with varying thicknesses of Ah horizons are associated with exceptionally steep sites where colluviation (i.e. soil creep) is or has been recently active. A few tracts in the Panther River and Dormer Creek drainages west of

the Bare Mountains in Banff display a compound landscape pattern resembling the Goat 2 (GT2) Ecosite. This pattern consists of grassland plus associated soils on steep, exposed, southerly aspects and closed Engelmann spruce-subalpine fir forest on relatively unexposed sites of all aspects. Soils associated with the Engelmann spruce-subalpine fir forest include Orthic Eutric Brunisols, Eluviated Eutric Brunisols and Cryosolic soils. Cryosolic soils occur on northerly aspects only and are associated with the Engelmann spruce-subalpine fir/rock willow/white mountain heather (C24) v.t. — a combination resembling the Snowflake 1 (SF1) Ecosite.

Vegetation

Exposure, steepness of slope, and southerly aspects are some factors controlling the dominant v.t.s, hairy wild rye-junegrass-bearberry (H14) and, at higher elevations in the Upper Subalpine, mountain avens-kobresia-bearberry (H4), of the TR2 Ecosite. Associated soils are rapidly to well drained. Scattered islands and krummholz of *Abies lasiocarpa* and *Picea engelmannii* are common, particularly with H4. Mountain avens-snow willow-moss campion (H1) and Engelmann spruce-subalpine fir/mountain avens (O19) occur sporadically on exposed sites. More protected portions of the landscape, such as lower slope fringes, depressions, and northerly aspects, have vegetation similar to TR1 — namely willow-dwarf birch-shrubby cinquefoil (S10), willow/hairy wild rye (S12), Engelmann spruce-subalpine fir/willow/hairy wild rye (O18), Engelmann spruce-subalpine fir/heather (O10), and other dry to moist, shrubby v.t.s. A few TR2 tracts in the Panther River and Dormer Creek drainages west of the Bare Mountains in Banff display a compound landscape pattern resembling the Goat 2 (GT2) Ecosite. This pattern consists of grassland and associated soils on steep, exposed, southerly aspects and closed Engelmann spruce-subalpine fir forest on relatively unexposed sites of all aspects. The Engelmann spruce-subalpine fir forest v.t.s include Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce/hairy wild rye (C33), and Engelmann spruce-subalpine fir/rock willow/white mountain heather (C24) with its Cryosolic soils. Tracts modified by avalanching (TR2A) include the hairy wild rye-wild strawberry-fireweed (H5) v.t. but occur infrequently. A plot representing vegetation of the pedon sample site described above (Table 357) and illustrating H4 on TR2 is presented in Table 358 and Plate 174.

Discussion

In terms of landform, physiographic position, and vegetation, TR2 resembles the steep, exposed, southerly aspect segments of the Goat 2 (GT2) Ecosite. However, GT2 is a Lower Subalpine Ecosite composed of northerly and southerly aspect segments, only the latter of which resemble TR2. The Wildflower 7 (WF7) Ecosite with its steep, linear slopes and grassland vegetation resembles TR2 but occurs on colluvial rather than morainal landforms. Some Eutric and Melanic Brunisols of the Peyto Lake 4 (PL4) Ecosite are morphologically similar to TR2 but usually have acidic rather than neutral upper sola with low rather than high base saturation. The TR1 Ecosite is distinguished from TR2 by the dry to moist, shrub dominated vegetation of the former (Table 354).

Table 358 Stand (PA8167) illustrating the mountain avens-kobresia-bearberry (H4) v.t. of the TR2 Ecosite.

	HERB-DWARF SHRUB LAYER
Agropyron spp.	01
Arctostaphylos uva-ursi	10
Arenaria capillaris	01
Bromus pumpellianus	01
Calamagrostis purpurascens	02
Carex scirpoides	.5
Danthonia intermedia	10
Dryas octopetala	35
Erigeron aureus	.5
Festuca saximontana	.5
Gentiana propinqua	01
Juniperus communis	.5
Kobresia myosuroides	.5
Luzula spicata	02
Phyllodoce glanduliflora	03
Poa cusickii	01
Sedum stenopetalum	.5
Solidago multiradiata	02
Trisetum spicatum	01
Vaccinium scoparium	.5
Selaginella densa	05
	BRYOID LAYER
Bryum spp.	.5
Cetraria islandica	.5
Tortula ruralis	03

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

TZ - TOPAZ ECOSECTION

The Topaz (TZ) Ecosection occurs on noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A) and noncalcareous, coarse textured glaciofluvial material (Glaciofluvial material A) in the Lower Subalpine portion of the Subalpine Ecoregion. The TZ Ecosection is dominated by Dystric Brunisols and lodgepole pine forest. Where topography with complex slopes produces a dry-wet landscape pattern, the same Dystric Brunisols and lodgepole pine forest are prevalent, while wet depressions have Gleysolic and Organic soils with wet coniferous open forest and shrub vegetation.

The TZ Ecosection occurs on valley floor and lower slopes only in the Main Ranges of Jasper, usually in association with Gog Group (quartzite) bedrock. The most extensive occurrences are in northern Jasper in valleys of

the Smoky, Snaring and upper Snake Indian Rivers and Blue Creek.

Two Ecosites (TZ1, TZ2) are recognized, based on the occurrence of a dry-wet versus an all dry landscape pattern of soil and vegetation. Table 359 shows general features of the TZ Ecosection.

A diagram of TZ Ecosites on the landscape is presented in Fig. 30.

TZ1 - TOPAZ 1 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, TZ1, occurs on two genetic materials, noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A) and noncalcareous, coarse textured glaciofluvial material (Glaciofluvial material A). Surficial expression of the former is often hummocky or ridged, while the latter is characterized by terraces. Eluviated Dystric Brunisols develop on these materials, and while some tracts may be mainly lodgepole pine/buffaloberry/twinflower (C19), most areas of TZ1 are the lodgepole pine-(Englemann spruce)/crowberry/lichen (C35) v.t.

The TZ1 Ecosite is found on valley floors and lower slopes of broad valleys with a gentle grade along their length and surrounded by noncalcareous bedrock. These conditions occur, though infrequently, in the Main Ranges often in association with Gog Group (quartzite) bedrock. The TZ1 Ecosite is mapped in Jasper only.

Geomorphology

The TZ1 Ecosite occurs on two related genetic materials, noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A) and noncalcareous, coarse textured glaciofluvial material (Glaciofluvial material A). Complex slopes are typical of the hummocky and ridged surfaces of the ice contact material. Much of the glaciofluvial material has simple slopes, but tracts overall are mapped as complex because of the terraced surface expression. Common slope range is from 2 to 45% with gentlest slopes found on the tread of the terraces. Terraces are best and most extensively expressed along much of the length of the Snaring River.

More stratification is found in the ice contact than the glaciofluvial material and textures are coarse in both. Coarse fragment content and angularity are also more variable both vertically and laterally in the ice contact material. Dominant quartzite lithology also contributes to coarseness of textures, as does the dominance of glaciofluvial processes in the formation of these landforms. Eskers and ice marginal channels are common features of the ice contact areas of TZ1.

There is little evidence of altered, medium textured eolian material (Eolian material B) on TZ1 except on tracts in southwestern Jasper such as those in the Whirlpool River valley.

Soils

The Eluviated Dystric Brunisols of the TZ1 Ecosite reflect the coarse textured, noncalcareous nature of the parent materials. These Eluviated Dystric Brunisols have thick, strongly eluviated A (Ae) horizons and deep, strongly colored Bm horizons. Occasionally pieces of rottenstone occur in the solum. Lower B horizons are usually weakly cemented (duric tendency). Soil development is generally uniform on this Ecosite. The pedon sampled in the Blue Creek valley to illustrate the soils of TZ2 also aptly illustrates the soils of TZ1 (Table 360 and Color Plate 78 in the TZ2 Ecosite description).

Soils on TZ1 are rapidly drained, with poorer drainage only infrequently in depressions in hummocky areas of ice contact materials or near breaks in slope from steeper surrounding landscapes. Soils of TZ1 tracts with altered, medium textured eolian material (Eolian

Table 359 General features of the Topaz (TZ) Ecosites.

Ecosite	Landform	Soils	Vegetation
TZ1	Ice Contact Stratified Drift A; ridged, hummocky and Glaciofluvial material A; terrace	Dystric Brunisol	lodgepole pine forest
TZ2	Ice Contact Stratified Drift A; ridged, hummocky	Dry[20]: Dystric Brunisol Wet[20]: Gleysolic > Organic	Dry[20]: lodgepole pine forest Wet[20]: coniferous open forest, shrubby meadow, birch fen

material B) occasionally have Bf horizons developed above the parent material disconformity.

Vegetation

Uniform vegetation development is a characteristic of TZ1. With few exceptions, tracts are dominated by lodgepole pine forest. Lodge-pole pine-(Engelmann spruce)/crowberry/lichen (C35) is found most commonly, but some tracts are mainly lodgepole pine/buffaloberry/twinflower (C19). A description that illustrates the vegetation of TZ2 also illustrates the vegetation of TZ1 (Table 361 and Plate 175 in the TZ2 Ecosite description).

Features of the modal vegetation on TZ1 such as the relatively high lichen cover reflect the more xeric and acidic surface conditions extant on the coarse textured, noncalcareous materials. However, in areas with a prolonged absence of fire and higher precipitation, Engelmann spruce-subalpine fir forests are found. For example, the TZ1 tract in the Short Creek valley has the Engelmann spruce-subalpine fir/false azalea (C14) v.t. In these cases, tracts surrounding the TZ1 tract are usually forested with Engelmann spruce-subalpine fir, as is the case at the confluence of Meadow and Crescent Creeks. Engelmann spruce-subalpine fir forest is occasionally found on portions of tracts close to the Upper Subalpine boundary, such as Englemann spruce-subalpine fir/tall bilberry/liverwort (C21) in the upper Snaring River valley. Downslope these same tracts are forested with lodgepole pine v.t.s modal for the Ecosite.

Engelmann spruce-subalpine fir/feathermoss (C13) and lodgepole pine/Labrador tea (C29) also occur locally on TZ1. The small, infrequent wet depressions have the vegetation characteristics of depressions in the TZ2 description.

Discussion

The TZ1 Ecosite is simple and uniform taxonomically in soil and vegetation. Variety in landform does not significantly alter these attributes.

Ecosites of the Moraine Lake (ML) Ecosection, especially ML2, resemble TZ1 but are distinguished because they are found on noncalcareous, coarse textured till (Till A), rather than on Ice Contact Stratified Drift A or Glaciofluvial material A. Also, ML is usually found higher on valley walls and has linear slopes. The glaciofluvial terraces of the Bow Valley (BV) Ecosection may be similar to portions of TZ1, but the Eutric Brunisols that form on the calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) differentiate BV from the Dystric Brunisols that form on TZ1. The Upper Subalpine Ecosite, Azure 1 (AZ1), has similar soils and landform on the upland portions of its dry-wet pattern, but has Engelmann spruce-subalpine fir forest vegetation. The dry-wet pattern of TZ2 is often mapped adjacent to TZ1 (Table 359).

A tract of TZ1 disturbed by fire (TZ1B) occurs on Calumet Creek just above its confluence with the Smoky River in Jasper. Other disturbances or combinations with Miscellaneous Landscapes do not occur because of the stable valley bottom positions and depositional genesis of the landform.

TZ2 - TOPAZ 2 ECOSITE

Ecosite Concept

The Lower Subalpine Ecosite, TZ2, occurs on hummocky and ridged noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A). This landform is characterized by a dry-wet landscape pattern dominated by upland segments with Eluviated Dystric Brunisol soils and frequently lodgepole pine-(Engelmann spruce)/crowberry/lichen (C35) vegetation. Lodgepole pine/buffaloberry/twinflower (C19) may dominate dry portions of some tracts. The poorly drained soils of depressions are Rego Gleysols more frequently than Terric Mesisols, with associated Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6), spruce/Labrador tea/brown moss (O11), dwarf birch-shrubby cinquefoil-willow/brown moss (S1) and dwarf birch-shrubby cinquefoil/needlerush (S3) v.t.s.

The TZ2 Ecosite occurs on the floors and lower slopes of broad valleys with gentle grades along their length and surrounded by noncalcareous bedrock. These conditions occur infrequently in the Main Ranges, often in association with Gog Group (quartzite) bedrock. Topaz 2 is mapped in Jasper only.

Geomorphology

The TZ2 Ecosite occurs mainly on noncalcareous, coarse textured ice contact stratified drift (Ice Contact Stratified Drift A) that has hummocky or ridged surface expression. Glaciofluvial processes appear to have been dominant in the creation of these ice contact landforms, as coarse stratified profile textures and features such as ice marginal channels and eskers are common. Dominant quartzite lithology also contributes to coarseness of textures.

Occasionally, TZ2 occurs on terraces of noncalcareous, coarse textured glaciofluvial material (Glaciofluvial material A), especially in the

Table 360 Pedon (Alberta 1979 No. 39) description of an Eluviated Dystric Brunisol of dry upland segments of the TZ2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: TZ2.

LOCATION: MILITARY GRID REF. 11 ULX 7345 2880; NTS MAP AREA 83E 7W.

CLIMATE: 1760 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER SOIL TEMP READING NO. 1 WAS 10 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: VPN=LC9168* VTH=C35*.

SOIL SITE: PARENT MATERIAL 1: COARSE LOAMY AND COARSE SILTY (<18% CLAY) AND SANDY, MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), GLACIOFLUVIAL AND MORAINAL (TILL), QUARTZITE; LANDFORM CLASSIFICATION: GLACIO FLUVIAL AND MORAINAL, HUMMOCKY; SLOPE: 16% COMPLEX SLOPE OF CLASS 6 (16-30%), FACING SOUTHEAST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,100 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; VERY STONY; NONROCKY.

SPECIAL NOTES: SSN=SC9089*APN=01B-125*PCP*1GR(2-5)3GR,4CB(6)1GR(7-8)*DATE=AUGUST 25,1979*SAMPLED IN AN AREA MAPPED AS TZ2*

LF: 2 TO 0 CM, RANGE 1 TO 3 CM; MATRIX MOIST ; FEW, FINE ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 13 CM, RANGE 7 TO 36 CM; MATRIX MOIST 10YR 6/1; FINE SANDY LOAM; MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MEDIUM ROOTS; VERY FEW, FINE PORES; WAVY, ABRUPT HORIZON BOUNDARY.

BM1: 13 TO 21 CM, RANGE 0 TO 10 CM; MATRIX MOIST 10YR 5/8; FINE SANDY LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; COMMON, VERY FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

BM2: 21 TO 30 CM, RANGE 0 TO 14 CM; MATRIX MOIST 10YR 7/6; SAND; VERY WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

BMC: 30 TO 43 CM, RANGE 0 TO 30 CM; MATRIX MOIST 7.5YR 5/8; FINE SANDY LOAM; MASSIVE STRUCTURE; FIRM CONSISTENCE; VERY FEW ROOTS; MODERATELY POROUS, COMMON, VERY FINE AND FINE PORES; WAVY, ABRUPT HORIZON BOUNDARY.

BM3: 43 TO 79 CM, RANGE 30 TO 40 CM; MATRIX MOIST 10YR 6/8; LOAMY SAND; VERY WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE ROOTS; WAVY, GRADUAL HORIZON BOUNDARY.

BC: 79 TO 100 CM, RANGE 18 TO 25 CM; MATRIX MOIST 10YR 6/6, MATRIX MOIST 10YR 6/8; SAND; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; .

C: 100 TO 135 CM; MATRIX MOIST 10YR 7/4; SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; .

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF								
AE	4.5	0.40	1.6		0.3	0.4	-.1	-.1
BM1	4.9	0.30	3.9		0.7	0.4	0.1	-.1
BM2	4.5	0.10	1.5		0.0	0.0	-.1	-.1
BMC	4.9	0.30	2.4		0.1	0.0	0.0	-.1
BM3	5.1	0.10	2.0		0.4	0.3	0.4	-.1
BC	6.0		0.9		0.6	0.1	-.1	-.1
C	4.9		0.5		-.1	0.0	-.1	0.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2
LF				
AE				
BM1	0.2		-.1	
BM2	-.1		-.1	
BMC	0.1		0.1	
BM3	-.1		-.1	
BC				
C				

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF															
AE						1	4	34	22	61		39	0		1.60
BM1					3	5	21	34	8	71		23	6		
BM2					1	7	36	41	6	91		8	1		
BMC					1	1	3	38	26	69		27	4		1.60
BM3					7	8	34	26	4	79		21	0		
BC					1	7	48	37	4	97		3	0		1.70
C	99	99	99	99	1	2	9	60	25	97		3	0		

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE	16.8		2.4										
BM1	17.4		3.1										
BM2													
BMC	17.8		2.2										
BM"													
BC	2.3		0.7										
C	6.9		0.7									40	18

Snaring River valley. This material is closely related to the ice contact material discussed above, and both soil and vegetation development remain similar.

In TZ2 the water table often reaches the surface in depressions between hummocks and ridges and in the bottoms of eroded ice marginal channels. Water here may make minor landform modifications, producing fluvial and fluviolacustrine veneers where small, often intermittent streams flow, and fens where ponded. The interaction of complex slopes and water table controls the dry-wet pattern. Slopes commonly range from 5 to 30%, with even more gentle slopes found on the tread of the infrequent terraces.

There is little evidence of altered, medium textured eolian material (Eolian material B) on any TZ2 tracts except in the Athabasca River valley below the Chaba River confluence.

Soils

A pattern of soils related to drainage is produced by the complex slopes of the landform. Rapidly drained uplands make up 70% of any tract on an average and are dominated by Eluviated Dystric Brunisols. These soils have features that reflect the coarse textured, noncalcareous parent materials such as thick, strongly eluviated Ae horizons, deep strongly colored Bm horizons and pieces of rottenstone in the solum. Lower B horizons are usually weakly cemented (duric tendency). A pedon sampled in Blue Creek valley that illustrates the upland soils of TZ2 is described in Table 360 and shown in Color Plate 93. The soils found in the poorly to very poorly drained depressions are influenced by the depth to the water table and the degree of landform modification. Rego Gleysols are the most common soils and are found with surface accretions of fluvial materials. These soils may have organic surface horizons up to 40 cm thick (peaty phase) and form a pattern in the depressions with the less frequently encountered Terric Mesisols on fens. Around the margins of depressions with transitional drainage and in wet depressions where the glacial materials are not modified by more recent fluvial or organic landform processes, Gleyed Dystric Brunisols and Orthic Gleysols are found.

Where altered, medium textured eolian material (Eolian material B) is present on the TZ2 tract in the Athabasca River valley below the Chaba River confluence some Podzolic soils have developed. Orthic Subgroups are occasionally found on uplands, with gleyed Subgroups in depressions.

Table 361 Stand (LC9165) illustrating the lodgepole pine-(Engelmann spruce)/crowberry/lichen (C35) v.t. of dry upland segments of the TZ2 Ecosite.

TREE LAYER	
Picea engelmannii	05
Pinus contorta	25
SHRUB LAYER	
Betula glandulosa	10
Pinus contorta	05
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	.5
Calamagrostis inexpansa	01
Cornus canadensis	05
Empetrum nigrum	10
Epilobium angustifolium	02
Gaultheria humifusa	.5
Juniperus communis	03
Phyllodoce spp.	03
Pinus contorta	02
Vaccinium caespitosum	02
Vaccinium vitis-idaea	02
BRYOID LAYER	
Cetraria ericetorum	.5
Cetraria islandica	03
Cetraria nivalis	.5
Cladonia bellidiflora	01
Cladonia cenotea	.5
Cladonia crispata	.5
Cladonia deformis	.5
Cladonia ecmocyna	05
Cladonia gonecha	02
Cladonia gracilis	01
Cladonia phyllophora	.5
Cladonia pyxidata	01
Cladonia mitis	12
Cladonia rangiferina	01
Cladonia stellaris	.5
Cladonia uncialis	01
Dicranum brevifolium	02
Dicranum scoparium	02
Grimmia laevigata	.5
Hylocomium splendens	01
Lecanora spp.	.5
Lecidea granulosa	.5
Peltigera aphthosa	.5
Peltigera rufescens	.5
Polytrichum juniperinum	.5
Rhizocarpon geographicum	.5
Stereocaulon alpinum	05
Umbilicaria hyperborea	.5
Barbilophozia lycopodioides	.5
EPIPHYTES	
Alectoria spp.	.5
Cyphelium tigillare	.5
Hypogymnia austerodes	.5
Lecanora varia	.5
Lecidea fuscescens	.5
Lecidea symmicta	.5
Letharia vulpina	.5
Parmelia sulcata	.5
Parmeliopsis ambigua	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Vegetation

A pattern of vegetation types related to drainage variation caused by complex slopes and depth to water table is found on TZ2. Drier uplands that generally make up 70% of a tract usually have the lodgepole

pine-(Engelmann spruce)/crowberry/lichen (C35) v.t., but some have dominantly lodgepole pine/buffaloberry/twinflower (C19). A plot from Blue Creek valley described at the same location as the pedon in Table 360 illustrates the C35 v.t. of TZ2 in Table 361 and Plate 175. The high lichen cover reflects the dry and acidic surface conditions found on the rapidly drained, coarse textured, noncalcareous material.

Other v.t.s occurring occasionally on upland portions of TZ2 include Engelmann spruce-subalpine fir/feathermoss (C13), Engelmann spruce-subalpine fir/false azalea (C14), Englemann spruce-subalpine fir/tall bilberry/liverwort (C21), and lodgepole pine/Labrador tea (C29) in areas of higher precipitation or close to the Upper Subalpine boundary. Lodgepole pine/buffaloberry/grouseberry (C18) is found on the tract in the Athabasca River valley.

Vegetation types on the wet depressions, which usually occupy 30% of a tract, are a manifestation of the depth to water table and recent landform modification. Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6), spruce/Labrador tea/brown moss (O11), dwarf birch-shrubby cinquefoil-willow/brown moss (S1), and dwarf birch-shrubby cinquefoil/needlerush (S3) are found on both wet fluvial and organic terrain. Any of these v.t.s, but especially the open forest types, may also be found on imperfectly and poorly drained positions on the unmodified ice contact material.

Discussion

Dry portions of the TZ2 Ecosite are simple and uniform taxonomically in landform, soil and vegetation. On a local scale characteristics are identical with those of the often adjacently mapped TZ1 Ecosite (Table 359). The subdominant, wet depressions are more complex, and except for their limited areal extent in any tract, would be classified as Ecosites within either the Consolation Valley (CV) or Hector (HC) Ecosections.

The dry-wet pattern of the TZ2 Ecosite distinguishes it from most other Ecosites. Local areas of ice contact material on Cavell 1 (CA1) tracts may be identical except for their dominant Engelmannn spruce-subalpine fir forest. Baker Creek 4 (BK4) displays a similar drainage pattern but is found on calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) that gives rise to different soil and, to a lesser extent, vegetation development. The dry-wet Azure 1 (AZ1) Ecosite is often mapped adjacent to, but across the Upper Subalpine-Lower Subalpine boundary from TZ2. The landform and soil of AZ1 and TZ2 are nearly identical, but Upper Subalpine v.t.s are found on AZ1.

Areas of TZ2 are subject to very little disturbance and are not found in combination with Miscellaneous Landscapes because of their stable positions in broad valley bottoms and the depositional genesis of the landform.

VD - VERDANT ECOSECTION

The Verdant Ecosection encompasses relatively stable fluvial landforms (fans and aprons) comprised of noncalcareous, coarse, stratified fluvial material (Fluvial material A) within the Lower Subalpine portion of the Subalpine Ecoregion. Brunisolic soils associated with spruce or pine forests dominate this Ecosection. The VD Ecosection occupies lower slopes and valley floors of main and tributary valleys throughout both parks.

Two Ecosites are differentiated (Table 362) within the Verdant Ecosection, mainly on differences in vegetation.

VD1 - VERDANT 1 ECOSITE

Ecosite Concept

The VD1 Ecosite occurs on relatively stable fluvial fans and aprons comprised of noncalcareous, coarse, stratified fluvial material (Fluvial material A). It is dominated by Orthic and Eluviated Dystric Brunisols and the Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/false azalea (C14) v.t.s.

Geomorphology

The VD1 Ecosite occurs on relatively stable fluvial fans and aprons comprised of noncal-

Table 362 General features of the Verdant (VD) Ecosites.

Ecosite	Landform	Soils	Vegetation
VD1	Fluvial material A; fan, apron	Dystric Brunisol	Engelmann spruce-subalpine fir forest
VD2	Fluvial material A; fan, apron	Dystric Brunisol	lodgepole pine forest

Table 363 Pedon (Alberta 1978 No. 28) description of an Eluviated Dystric Brunisol of the VD1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: VD1.

LOCATION: MILITARY GRID REF. 11 UNJ 3868 2945; NTS MAP AREA 830 9W.

CLIMATE: 1270 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER SOIL TEMP READING NO. 1 WAS 8 DEG(C) AT 20 CM IN SEPTEMBER, NO. 2 WAS 8 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=SJB188*VTH=C31*.

SOIL SITE: PARENT MATERIAL 1: SANDY, MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), FLUVIAL, QUARTZITE; LANDFORM CLASSIFICATION: FLUVIAL, FAN; SLOPE: 10% SIMPLE SLOPE OF CLASS 5 (10-15%), FACING EAST, SITE AT MIDDLE POSITION, MODERATELY MOUNDED MICROTOPOGRAPHY.; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED AND WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; NONSTONY; NONROCKY.

SPECIAL NOTES: SSH=DA8093*APH=015-027*PCF=1CB(5)2BR,2CB,1ST(7)**LFJ=FF*

LF: 6 TO 0 CM, RANGE 5 TO 8 CM; HORIZON MOIST; SINGLE GRAIN SECONDARY STRUCTURE; FEW AND PLENTIFUL, FINE AND MEDIUM AND COARSE, HORIZONTAL ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 5 CM, RANGE 4 TO 7 CM; HORIZON MOIST; MATRIX MOIST 10YR 7/4; LOAMY SAND; VERY WEAK, VERY FINE TO FINE, PLATY STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM AND VERY FINE, HORIZONTAL ROOTS; HIGHLY POROUS; 10% GRAVELLY AND COBBLY COARSE FRAGMENTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

BM: 5 TO 13 CM, RANGE 6 TO 14 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/6; FINE SANDY LOAM; VERY WEAK, VERY FINE TO FINE, PLATY STRUCTURE; STRUCTURELESS SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM AND VERY FINE, HORIZONTAL ROOTS; HIGHLY POROUS; 20% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

HB1: 13 TO 15 CM, RANGE 1 TO 2 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/1; ORGANIC; FEW, FINE AND VERY FINE, HORIZONTAL ROOTS; HIGHLY POROUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

BC: 15 TO 64 CM, RANGE 58 TO 53 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/6; SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE AND VERY FINE, RANDOM ROOTS; HIGHLY POROUS; 10% GRAVELLY AND COBBLY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

HB2: 64 TO 67 CM, RANGE 2 TO 7 CM; HORIZON MOIST; MATRIX MOIST 5YR 3/2; ORGANIC; VERY FEW, VERY FINE, RANDOM ROOTS; HIGHLY POROUS; IRREGULAR, CLEAR HORIZON BOUNDARY.

C: 67 TO 82 CM; HORIZON MOIST; MATRIX MOIST 10YR 7/3; LOAMY SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; VERY FEW, VERY FINE, RANDOM ROOTS; HIGHLY POROUS; 30% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	5.8	46.78						
AE	4.7	0.10	3.7		1.0	0.2	0.0	0.1
BM	4.3	0.10	3.3		0.2	0.1	0.1	0.1
HB1								
BC	5.5		2.2		1.7	0.6	0.1	0.1
HB2								
C	6.1		1.2		1.3	0.4	<.1	<.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	0.1		<.1	
HB1				
BC				
HB2				
C				

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE						4	19	40	15	78		18	4	
BM					4	10	20	28	12	74		21	5	
HB1														
BC					2	9	20	26	11	68		26	6	
HB2														
C					7	16	28	24	6	81		15	4	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST
LF					
AE		3.2	1.2		
BM					
HB1					
BC		7.4	1.4		
HB2					
C					

careous, coarse, stratified fluvial material (Fluvial material A). Irregular surfaces produced by channelling are a common feature. Slopes of VD1 are commonly linear ranging between 2 and 45%. Fluvial blankets and veneers overlying morainal landforms occasionally characterize portions of tracts mapped as VD1. Surficial veneers containing volcanic ash material also occur occasionally on VD1 tracts located in western Banff and southwestern Jasper and sporadically elsewhere. These surficial veneers may be altered, medium textured eolian material (Eolian material B) or water reworked eolian material.

Soils

The VD1 Ecosite is characterized by well to moderately well drained Orthic and Eluviated Dystric Brunisols with the latter being dominant. The degree of development of these soils reflects geomorphic stability. Orthic Humo-Ferric Podzols are accessory soils occasionally found on the few tracts of VD1 where veneers of Eolian material B occur. Orthic Regosols are accessory soils that occur along present and recently abandoned stream channels and are subject to episodic erosion or sedimentation. The pedon described in Table 363 and shown in Color Plate 79 illustrates an Eluviated Dystric Brunisol of the VD1 Ecosite.

The above soil pedon description has two buried H horizons that indicate alternate periods of geomorphic activity and stability.

Vegetation

The VD1 Ecosite is dominated by the Engelmann spruce-subalpine fir/feathermoss (C13) and Engelmann spruce-subalpine fir/false azalea (C14) v.t.s. The C13 v.t. occurs more often than does the C14 v.t. but some tracts, particularly those located close to the Continental Divide, are dominated by C14. Engelmann spruce-subalpine fir/ hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) occurs as an accessory v.t. on a few eastern tracts of VD1. Table 364 illustrates the C13 v.t. commonly found on VD1.

Discussion

The VD1 Ecosite resembles the Altrude 2 (AL2) and Pipestone 3 (PP3) Ecosites in landform and vegetation. However, AL2 and PP3 occur on fluvial landforms comprised of calcareous, coarse, stratified fluvial material (Fluvial material B), rather than the noncalcareous Fluvial material A characterizing VD1. Further, AL2 is dominated by Eutric, rather than Dystric Brunisols and PP3 is dominated by Orthic and Cumulic Regosols that reflect a more active geomorphic environment.

Table 364 Stand (JC9068) illustrating the Engelmann spruce-subalpine fir/feathermoss (C13) v.t. of the VD1 Ecosite.

TREE LAYER	
Abies lasiocarpa	01
Picea engelmannii	29
TALL SHRUB LAYER	
Abies lasiocarpa	02
SHRUB LAYER	
Abies lasiocarpa	02
Ledum groenlandicum	05
Picea engelmannii	.5
Salix spp.	.5
HERB-DWARF SHRUB LAYER	
Arnica cordifolia	03
Cornus canadensis	05
Elymus innovatus	02
Linnaea borealis	05
Pyrola secunda	.5
Vaccinium membranaceum	05
Vaccinium vitis-idaea	01
Lycopodium annotinum	15
BRYOID LAYER	
Hylocomium splendens	40
Peltigera aphthosa	01
Pleurozium schreberi	40
Ptilium crista-castrensis	15
EPIPHYTES	
Bryoria glabra	.5
Buellia triphragmoides	.5
Cetraria chlorophylla	.5
Letharia vulpina	.5
Parmeliopsis ambigua	.5
Usnea alpina	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

VD2 - VERDANT 2 ECOSITE

Ecosite Concept

The VD2 Ecosite occurs on relatively stable fluvial fans and aprons comprised of noncalcareous, coarse, stratified fluvial material (Fluvial material A). It is dominated by Orthic and Eluviated Dystric Brunisols and the lodgepole pine/buffaloberry/ twinflower (C19) and lodgepole pine/false azalea/grouseberry (C20) v.t.s.

Geomorphology

The VD2 Ecosite occurs on relatively stable fluvial fans and aprons comprised of noncalcareous, coarse, stratified fluvial material (Fluvial material A). Irregular surfaces produced by channeling are a common feature. Slopes of VD2 are commonly linear, ranging from 2 to 45%. Fluvial blankets and veneers

overlying morainal landforms occasionally characterize portions of tracts mapped as VD1. Veneers of (Eolian material B) occur on VD2 in western Banff and southwestern Jasper, and sporadically elsewhere.

Soils

Well drained Orthic and Eluviated Dystric Brunisols dominate VD2. The degree of development of these soils reflects geomorphic stability. Orthic Regosols are accessory soils that occur along present and recently abandoned stream channels and are subject to episodic erosion or sedimentation. The pedon chosen to describe VD1 also illustrates Eluviated Dystric Brunisols of the VD2 Ecosite (Table 363).

Vegetation

The VD2 Ecosite is dominated by lodgepole pine/buffaloberry/twinflower (C19) and lodgepole pine/false azalea/grouseberry (C20) v.t.s. The C19 v.t. occurs more often than C20 but some tracts, particularly those located close to the Continental Divide, are dominated by C20. Lodgepole pine/dwarf bilberry (C9) occurs only in Banff, primarily in the Bow River valley between Lake Louise and Eisenhower Junction. The accessory v.t. lodgepole pine/feathermoss (C11) and minor amounts of lodgepole pine/green alder/feathermoss (C10) are commonly associated with VD2 on northerly aspects in the Main Ranges. The vegetation plot description in Table 365 illustrates the C19 v.t. on VD2.

Discussion

The VD2 Ecosite resembles the Altrude 1 (AL1) and Pipestone 1 (PP1) Ecosites in landform and vegetation. The noncalcareous (Fluvial material B) distinguishes VD2 from the calcareous, coarse, stratified fluvial material (Fluvial material B) of AL1 and PP1. Also, AL1 is dominated by Eutric, rather than Dystric, Brunisols and PP1 is dominated by Orthic and Cumulic Regosols that reflect a more active geomorphic environment. The VD2 Ecosite may also appear similar to some tracts of Topaz 1 and 2, but the latter is differentiated by having coarser, more cobbly glacial and glaciofluvial materials.

VL - VERMILION LAKES ECOSECTION

The Vermilion Lakes Ecosection is complex and encompasses wet fluvial and fluviolacustrine landforms throughout the Montane Ecoregion in Banff and Jasper. Gentle slopes on level plains, aprons, and fans are characteristic. These landforms consist of calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) and the low coarse fragment content phase of calcareous, coarse, stratified fluvial material (Fluvial material B). Horizontal fens that thinly mantle the fluvial and fluviolacustrine materials on the wettest localities also occur on some VL Ecosites.

Table 365 Stand (AW5056) illustrating the lodgepole pine/buffaloberry/twinflower (C19) v.t. of the VD2 Ecosite.

TREE LAYER	
Picea engelmannii	04
Pinus contorta	30
TALL SHRUB LAYER	
Picea engelmannii	05
SHRUB LAYER	
Abies lasiocarpa	01
Juniperus communis	09
Lonicera involucrata	.5
Picea engelmannii	01
Populus tremuloides	.5
Potentilla fruticosa	.5
Rosa acicularis	01
Salix glauca	01
Shepherdia canadensis	05
HERB-DWARF SHRUB LAYER	
Achillea millefolium	01
Antennaria nitida	01
Arctostaphylos uva-ursi	04
Arnica cordifolia	01
Aster ciliolatus	.5
Astragalus alpinus	01
Chimaphila umbellata	.5
Cornus canadensis	02
Elymus innovatus	12
Epilobium angustifolium	.5
Fragaria virginiana	04
Galium boreale	.5
Linnaea borealis	40
Oxytropis viscida	01
Pyrola secunda	.5
Pyrola virens	.5
Senecio indecorus	.5
Trisetum montanum	02
Vaccinium caespitosum	13
Lycopodium annotinum	.5
Lycopodium complanatum	01
BRYOID LAYER	
Cladonia spp.	01
Dicranum scoparium	02
Hylocomium splendens	.5
Peltigera aphthosa	01
Peltigera canina	03
Pleurozium schreberi	15
Polytrichum juniperinum	04
Stereocaulon tomentosum	01
Tiemia megapolitana	.5
EPIPHYTES	
Alectoria sp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Gleysolic soils which lack pedogenic horizonation characterize VL. Organic soils and gleyed Regosols are also common on some VL Ecosites. Various groupings of sedge fen, wet shrubby meadow, wet shrub thicket, and wet white spruce forest differentiate the four VL Ecosites as outlined in Table 366.

The VL Ecosection most often occurs on valley floors adjacent to major rivers (e.g. Bow, Howse, and North Saskatchewan Rivers in Banff; Athabasca and Miette Rivers in Jasper). Attendant high water tables account for its wetness. The mineral landforms of VL were and are continuing to be formed in quiet water and backwater depositional environments. Channels of silt-laden glacial rivers were constricted at various points creating backwater and quiet water floodplains for siltation and fluvial deposition (e.g. Bow River above Tunnel Mountain and the Forty Mile Creek fan in Banff; the Athabasca River at Bedson Ridge and the Fiddle River fan in Jasper). Episodic flooding favoring siltation alternating with low water conditions favoring fluvial deposition along the distributary channels account for the interbedding of fluvial and fluviolacustrine deposits on several VL Ecosites. Alternately, some backwater localities are characterized by fluviolacustrine deposits alone, while other localities are characterized by fluvial deposits. Both deposits are notably free of coarse fragments. Rutter (1965) reports that water-laid deposits range from 3 to over 60 m thick in the Bow River floodplain west of Banff townsite. The proportion of these deposits that are fluvial and fluviolacustrine sediments, which typify the VL Ecosection, is unknown. Some backwater localities are presently inundated by relatively sediment-free waters thereby allowing the development of surface organic layers.

Typical valley floor VL landscape, notably VL1 and VL3, is shown in Plate 176. Bow Valley Naturalists (1978) presented a study of this area, known as the Vermilion Lakes Interpretive Unit. A few tracts also occur on the benchlands of the Miette and Athabasca River valleys near Jasper townsite. These are associated with stream channels and lake margins (e.g. Pyramid Lake). The VL5 Ecosite is shown on a benchland in Fig. 50.

VL1 - VERMILION LAKES 1 ECOSITE

Ecosite Concept

The Montane Ecosite, VL1, encompasses ponded, fluviolacustrine, backwater floodplains dominated by fen vegetation. This landform consists primarily of calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B). Where siltation is no longer active due to the low sediment loads of inundating waters, organic material accumulation is occurring. Thus, horizontal fens that thinly mantle the fluviolacustrine deposits occur frequently. The floodplain surfaces are usually eroded (channeled) with slightly elevated, gently sloping levees bordering the channels. Pools, ponds, and small lakes usually dot the landscape.

The poorly to very poorly drained soils of VL1 reflect the geomorphic environment in their development. Amount of organic matter accumulations on the surface reflects the varying sediment loads of inundating waters and changes in sediment loads over time. Rego Gleysols and Terric Mesisols are dominant with the Rego Gleysols being more abundant. A vegetation pattern reflecting degree of ponding characterizes VL1. The water sedge-beaked sedge (H11) v.t. is dominant and occurs on ponded localities. Variants of H11 reflect degree of siltation. The dwarf birch-shrubby cinquefoil-willow/brown moss (S1) and willow/horsetail (S7) v.t.s are subdominant and occur on the slighty elevated levees and tract fringes.

Table 366 General features of the Vermilion Lakes (VL) Ecosites.

Ecosite	Landform	Soils	Vegetation
VL1	Fluviolacustrine material B; level and horizontal fen	Gleysolic, Organic	sedge fen > wet shrubby meadow, wet shrub thicket
VL3	Fluvial material B, Fluviolacustrine material B; level	Gleysolic	wet white spruce forest > wet shrubby meadow, wet shrub thicket
VL4	Fluvial material B; level, apron, fan and Fluviolacustrine material B; level	Gleysolic	wet white spruce forest
VL5	Fluvial material B; level, apron, fan and Fluviolacustrine material B; level	Gleysolic > Regosolic	wet shrub thicket

Geomorphology

The VL1 Ecosite is typified by level fluviolacustrine floodplains consisting primarily of calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B). The VL1+SC tract at Saskatchewan Crossing in Banff is dominated by calcareous, coarse, stratified fluvial material (Fluvial material B) and calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) although Fluviolacustrine material B also occurs on backwater reaches. A Fluvial material B phase characterized by low coarse fragment contents occurs locally in and adjacent to main stream channels and as layers within the fluviolacustrine material. A low lime variant of Fluvial material B, also with few coarse fragments, dominates a few tracts in western Jasper, particularly in the Miette River valley to Jasper townsite. Altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) occurs as veneers on some of the benchland VL1 tracts. These often occupy the toes of aprons and fans (e.g. the VL1 tract at Pyramid Lake in Jasper). Depth of fluviolacustrine material plus underlying gravelly and sandy fluvial and glaciofluvial deposits ranges from 3 to over 60 m on the Bow River floodplain west of Banff townsite (Rutter 1965). However, the proportion of fluviolacustrine material is unknown.

Ponding characterizes VL1 but the sediment load of inundating waters governs the geomorphic environment. Siltation from silt-laden glacial meltwater occurs on several tracts, particularly those in the Athabasca River valley in Jasper. Appreciable accumulation of organic material does not occur under such conditions, although the fluviolacustrine material often contains thin, fibrous, silt- and clay-laden, organic layers and pockets. On some areas and localities sediment loads decrease over time thereby reducing siltation and allowing organic material build-up as the moss layer develops. This peat is derived primarily from sedges and brown mosses (e.g. *Tomenthypnum nitens* and *Aulacomnium palustre*) and rarely exceeds 1.2 m in thickness. Moderate decomposition is characteristic but fibric and humic layers also occur. Occasionally, wood fragments occur in both the organic and fluviolacustrine deposits. Where the peat is >40 cm thick, the landform is classified as horizontal fen (C.S.S.C. 1978b). Horizontal fens dominate some VL1 tracts (e.g. surrounding Vermilion Lakes in Banff).

Topographically, VL1 displays gentle linear slopes on level, backwater floodplains. Slopes commonly range from 0 to 1%, 0 to 2% when including tracts that occupy the toes of fans and aprons. Slope continuity is broken by numerous abandoned and active, distributary stream channels meandering across the landscape (Eroded modifier, C.S.S.C. 1978b). Gently sloping, slightly elevated levees border the channels. Except for the levees and tract margins, VL1 is usually inundated with water. Pools, ponds, and small lakes are common and typical.

Soils

The VL1 Ecosite is dominated by Rego Gleysols and Terric Mesisols with the Rego Gleysols being most abundant. Some tracts, however, are dominated by Terric Mesisols (e.g. the VL1 tract at Vermilion Lakes in Banff). These poorly to very poorly drained soils are subjected to prolonged periods of saturation that promote strong gleying but inhibit pedogenic horizonation. Soil differences are governed by differences in the geomorphic environments, namely sedimentation versus organic matter accumulation. Soils in active siltation environments lack surface peat layers (Rego Gleysols). On areas and localities where sediment loads have decreased, surface organic layers have accumulated under well developed moss layers. Soils of these geomorphically inactive environments include Terric Mesisols and peaty phase Rego Gleysols. Organic soils with subdominant humic or fibric layers may also occur. The elevated levees are dominated by poorly drained Rego Gleysols, with or without surface peat layers depending on the frequency of fluvial deposition. Humic Gleysols and Orthic Gleysols occur in minor amounts on the levees. A pedon illustrating Terric Mesisols of VL1 is described in Table 367. The sample site and the water sedge-beaked sedge (H11) v.t. is shown in Plate 77.

Vegetation

A vegetation pattern reflecting degree of ponding characterizes the VL1 Ecosite. The water sedge-beaked sedge (H11) v.t. is dominant and occurs on ponded localities. A bryoid poor variant of H11 is associated with active siltation environments and the non-peaty Rego Gleysols. A better developed moss layer characterizes H11 where sediment loads of inundating waters are relatively low. This central concept of H11 is associated with Terric Mesisols and peaty phase. A plot illustrating H11 on the Vermilion Lakes 1 (VL1) Ecosite is described in Table 368. This plot is located in the adjacent VL3 tract <3 km downstream from the pedon sample site (Table 367). Landform, soil, and vegetation characteristics of the plot site better represent VL1 than VL3, but the areal extent of this VL1 landscape is so small that it cannot be delineated at a map scale of 1:50,000.

Table 367 Pedon (Alberta 1976 No. 97) description of a Terric Mesisol of the VL1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: TERRIC MESISOL. SOIL MAP UNIT: NOTATION: VL1.

LOCATION: MILITARY GRID REF. 11 UNS 9620 7000; NTS MAP AREA 82O 4E.

CLIMATE: 1400 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS VERY GOOD RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 0 DEG(C) AT 0 CM IN OCTOBER.

VEGETATION: VTN=H11*.

SOIL SITE: PARENT MATERIAL 1: WEAKLY CALCAREOUS (1 TO 6% CACO3), ORGANIC; PARENT MATERIAL 2: UNSPECIFIED WEATHERING, FINE LOAMY AND FINE SILTY (18 TO 35% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), FLUVIOLACUSTRINE; ORGANIC DEPOSIT IS 0.8 M; LANDFORM CLASSIFICATION: FEH; SLOPE: 0% SIMPLE SLOPE OF CLASS 1 (0-0.5%), FACING LEVEL, LEVEL MICROTOPOGRAPHY,1000 M LONG; SOIL MOISTURE AND DRAINAGE: VERY POORLY DRAINED, PONDED SURFACE RUNOFF; NONSTONY; NONROCKY; PRESENT LAND USE: OUTDOOR RECREATION, FEN, WATER.

SPECIAL NOTES: SSN=BW6116*APH=011-014*RLU=15*MLU=H3,F1*FEN PLACES HAVE ABOUT 5 CM MUCKY MINERAL SOIL ON SURFACE*STANDING WATER ABOUT 20CM DEEP*LFH*HH/FLL*

OF: 0 TO 25 CM; MATRIX MOIST 10YR 2/2, RUBBED WET/OXIDIZED 10YR 2/2; MATERIAL COMPOSITION 1% SEDGE AND REED, SLIGHT DECOMPOSITION; ABUNDANT, VERY FINE AND FINE AND MEDIUM, RANDOM ROOTS; VERY WEAK EFFERVESCENCE; WEAKLY CALCAREOUS.

OM1: 25 TO 50 CM; MATRIX MOIST 10YR 2/1, RUBBED WET/OXIDIZED 10YR 2/1; MATERIAL COMPOSITION 1% SEDGE AND REED, MODERATE DECOMPOSITION; ABUNDANT, VERY FINE AND FINE, RANDOM ROOTS; WEAK EFFERVESCENCE; WEAKLY CALCAREOUS.

OM2: 50 TO 63 CM; MATRIX MOIST 10YR 2/2, RUBBED WET/OXIDIZED 10YR 2/1.5; MATERIAL COMPOSITION 1% SEDGE AND REED, MODERATE DECOMPOSITION; PLENTIFUL, VERY FINE AND FINE, RANDOM ROOTS; WEAK EFFERVESCENCE; WEAKLY CALCAREOUS.

OM3: 63 TO 78 CM; MATRIX MOIST 10YR 2/2, RUBBED WET/OXIDIZED 10YR 2/1.5; MATERIAL COMPOSITION 1% SEDGE AND REED, MODERATE DECOMPOSITION; PLENTIFUL, VERY FINE AND FINE, RANDOM ROOTS; WEAK EFFERVESCENCE; WEAKLY CALCAREOUS.

CKG: 78 TO 91 CM; MATRIX MOIST 2.5YR 3/2; MUCKY CLAY; STRUCTURELESS STRUCTURE; NONSTICKY, NONPLASTIC CONSISTENCE; FEW, VERY FINE, RANDOM ROOTS; MODERATE EFFERVESCENCE; VERY STRONGLY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
OF	7.0	31.90	1.4
OM1	7.0	28.20	6.0
OM2	6.9	42.20	1.3
OM3	6.7	33.30	1.1
CKG	6.8	8.30	28.2

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
OF								
OM1								
OM2								
OM3								
CKG	25.0	82.0		26.0	1.5			

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS % PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
OF														
OM1														
OM2														
OM3														
CKG										21		49	30	7

Table 368 Stand (KS6054) illustrating the water sedge-beaked sedge (H11) v.t. of the VL1 and VL3 Ecosites.

	HERB-DWARF SHRUB LAYER
Carex aquatilis	30
Carex nardina	05
Epilobium palustre	.5
Galium trifidum	03
Lemna minor	08
Petasites sagittatus	20
Poa palustris	.5
Rumex spp.	.5
Equisetum fluviatile	15
	BRYOID LAYER
Drepanocladus uncinatus	03

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

The dwarf birch-shrubby cinquefoil-willow/brown moss (S1) and willow/horsetail (S7) v.t.s are subdominant and occur on infrequently ponded localities, namely the poorly drained natural levees and tract fringes. The S1 v.t. is more abundant in geomorphically inactive environments, its associated soils usually having surface peat layers. The S7 v.t. occurs on active depositional localities. Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6) and spruce/Labrador tea/brown moss (O11) occur in minor amounts on elevated levees and tract margins. Spruce/arrowgrass-sedge (O7), sedge-saxifrage (H3), and yellow dryad-willow herb (H8) are important accessory v.t.s. The O7 v.t. occurs sporadically on the lower Athabasca River valley in Jasper and the North Saskatchewan River valley in Banff and is especially common on a VL1 tract encompassing the toe of

the Snaring River fan in Jasper. The H3 and H8 v.t.s occur along stream borders and are especially common on the VL1+SC tract with coarser textured parent materials on the lower Howse and North Saskatchewan River floodplains in Banff. More than 50% of this tract is unvegetated because of the numerous, meandering stream channels (braiding) and active fluvial and glaciofluvial deposition. Backwater floodplains on this VL1+SC tract are dominated by H11.

Discussion

The VL1 Ecosite encompasses backwater floodplains dominated by sedge fen in the Montane Ecoregion. It resembles the Hector 2 (HC2) and Num-Ti-Jah 3 (NT3) Ecosites which are its Lower Subalpine and Upper Subalpine counterparts, respectively. Also, in contrast to VL1, HC2 is confined to active siltation environments, a feature reflected by its non-peaty soils and species-poor, bryoid-poor sedge fen vegetation. Like VL1, NT3 has peaty soils reflecting an inactive siltation environment but NT3 occurs primarily on noncalcareous, rather than calcareous, fluviolacustrine deposits. Wet segments of the Patricia 5 (PT5) and Nashan 1 (NH1) sometimes resemble VL1 but they are respectively, part of a compound dry > wet or wet > dry landscape pattern which distinguish them from VL1. The more varied geomorphic environments, past and present, affecting VL3, VL4, and VL5 have resulted in the co-dominance of fluvial and fluviolacustrine deposits, rather than thin Organic deposits characterizing VL1. (Table 366).

VL3 - VERMILION 3 ECOSITE

Ecosite Concept

The Montane Ecosite, VL3, encompasses wet level floodplains dominated by forest and shrub vegetation. The floodplains consist of calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) and the coarse fragment free phase of calcareous, coarse, stratified fluvial material (Fluvial material B). The floodplain surfaces are usually eroded (channelled) with slightly elevated, gently sloping levees bordering the channels.

Poorly drained Rego Gleysols, with or without surface peat layers, are dominant. Vegetation of VL3 is complex and is best represented by a pattern in which white spruce/prickly rose/horsetail (C4) is dominant and dwarf birch-shrubby cinquefoil-willow/brown moss (S1) and willow/horsetail (S7) are subdominant.

Geomorphology

The VL3 Ecosite is typified by level floodplains consisting of calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) and the coarse fragment free phase of calcareous, coarse, stratified fluvial material (Fluvial material B). A low lime variant of Fluvial material B, also with few coarse fragments, dominates a few tracts in western Jasper, particularly in the Miette and Athabasca River valleys east and north to Jasper townsite. The fluviolacustrine material indicates deposition by siltation from silt-laden glacial melt water in backwater localities. The fluvial material infers deposition from quiet water in and adjacent to the numerous distributary channels. Interlayering of the two deposits demonstrates the dynamics of depositional environments over time across the landscape. Presence of thin organic layers, incorporated in the mineral deposits and mantling the surface, indicate periods of little or no sedimentation. Horizontal fens, with 40 to 120 cm of moderately decomposed peat, occur locally on ponded sites. The VL3 Ecosite is not extensively ponded like VL1, but experiences episodic flooding, particularly following spring snow melt.

Topographically, VL3 displays gentle linear slopes on level floodplains. Slopes commonly range from 0 to 2%. Slope continuity is broken by numerous abandoned and active, distributary stream channels meandering across the landscape (Eroded modifier, C.S.S.C. 1978b). Gently sloping, slightly elevated levees border the channels. Weakly expressed terracing (risers <1 m) is a minor feature.

Soils

Poorly drained Rego Gleysols dominate the VL3 Ecosite. Prolonged periods of saturation (high water tables) plus recent and continuing sedimentation have inhibited pedogenic development other than gleization. Thin peat layers occur at the surface on many VL3 soils, its presence governed by the amount of fluvial and fluviolacustrine deposition in recent times. Gleyed Cumulic Regosols and Terric Mesisols are important accessory soils. The imperfectly drained Gleyed Cumulic Regosols are most abundant on the slightly elevated, natural levees and tract fringes. Terric Mesisols are associated with horizontal fens occupying ponded localities where siltation is not occurring (e.g. VL3 tracts near Banff townsite). The water sedge-beaked sedge (H11) v.t. is associated with the very poorly drained Terric Mesisols. Humic Gleysols and other gleyed Regosolic soils occur in minor amounts. A pedon illustrating Rego Gleysols of VL3 is described in Table 369. The sample site is shown Plate 177.

Table 369 Pedon (Alberta 1978 No. 87) description of a Rego Gleysol of the VL3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: REGO GLEYSOL. SOIL MAP UNIT: NOTATION: VL3.

LOCATION: MILITARY GRID REF. 11 UNG 9810 6990; NTS MAP AREA 820 4E.

CLIMATE: 1380 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS VERY GOOD RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 1 DEG(C) AT 50 CM IN MAY.

VEGETATION: VPN=JD8001*VTN=C04*..

SOIL SITE: PARENT MATERIAL 1: COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), FLUVIAL; LANDFORM CLASSIFICATION: FLUVIAL, ERODED(CHANNELLED), LEVEL; SLOPE: 1% SIMPLE SLOPE OF CLASS 2 (0.5-2%), FACING LEVEL, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,1000 M LONG; SOIL MOISTURE AND DRAINAGE: POORLY DRAINED, MODERATELY PERVIOUS, VERY SLOW SURFACE RUNOFF, SEEPAGE ABSENT, 0.8 M TO APPARENT WATERTABLE; NONSTONY; NONROCKY.

SPECIAL NOTES: SSN=BW8004*APN=010-222*RLU=15*AHKBG NOT SAMPLED*NO COARSE FRAGMENT*LFH=FL-E*ACKG HORIZON DEVELOPED IN FLUVIOLACUSTRINE MATERIAL*

OH: 6 TO 4 CM, RANGE 3 TO 6 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/1; PLENTIFUL, FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

OH: 4 TO 0 CM, RANGE 3 TO 5 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/1; PLENTIFUL, FINE ROOTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

ACKG: 0 TO 5 CM, RANGE 3 TO 7 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/1; SILTY CLAY LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; WEAK, FINE, GRANULAR SECONDARY STRUCTURE; SLIGHTLY STICKY, VERY FRIABLE, NONPLASTIC CONSISTENCE; ABUNDANT, FINE AND MEDIUM AND COARSE ROOTS; STRONG EFFERVESCENCE; VERY STRONGLY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CKG1: 5 TO 28 CM, RANGE 22 TO 25 CM; HORIZON MOIST; MATRIX MOIST 2.5Y 4.5/2; SILT LOAM; MANY, MEDIUM, DISTINCT, 10YR 4/4 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; SLIGHTLY STICKY, VERY FRIABLE, NONPLASTIC CONSISTENCE; PLENTIFUL, FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

AHKBG: 28 TO 30 CM, RANGE 1 TO 3 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/1; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SLIGHTLY STICKY, VERY FRIABLE, NONPLASTIC CONSISTENCE; PLENTIFUL, FINE ROOTS; STRONG EFFERVESCENCE.

CKG2: 30 TO 90 CM; HORIZON WET; MATRIX MOIST 2.5Y 4.5/2; SILT LOAM; MANY, MEDIUM, PROMINENT, 10YR 4/6 MOTTLES; STRUCTURELESS, MASSIVE STRUCTURE; SLIGHTLY STICKY, VERY FRIABLE, NONPLASTIC CONSISTENCE; FEW, FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
OH	7.3	33.10	3.9
OH	6.2	45.60	
ACKG	8.0	7.50	39.9
CKG1	8.0	0.60	36.0
AHKBG			
CKG2	7.9	0.70	50.2

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS													
	% PASSING										% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
OH														
OH														
ACKG										4		63	33	
CKG1										40		53	7	
AHKBG														
CKG2										31		58	11	

Vegetation

Vegetation of the VL3 Ecosite is complex and is best represented by a pattern in which the white spruce/prickly rose/horsetail (C4) v.t. is dominant and the dwarf birch-shrubby cinquefoil-willow/brown moss (S1) and willow/horsetail (S7) v.t.s are subdominant. The S1 and S7 v.t.s break up the closed forest continuity by occurring frequently in small patches and ribbons. Their areal extent is low. The S1 v.t. is more abundant in geomorphically inactive localities, whereas S7 occurs primarily on active or recently active depositional sites. Balsam poplar/horsetail (C28), white spruce/shrubby cinquefoil/bearberry (O3), and water sedge-beaked sedge (H11) are important accessory v.t.s. The C28 v.t. occurs mostly on actively aggrading, elevated, imperfectly drained, natural levees along major stream channels (e.g. the Bow River), whereas O3 occurs on imperfectly drained, non-aggrading sites with relatively dry surface conditions. On ponded localities, H11 occurs associated with very poorly drained Rego Gleysols and Terric Mesisols. Small areas of various v.t.s are numerous, notable ones being Engelmann spruce/horsetail/feathermoss (C32), spruce/arrowgrass-sedge (O7), and moist to wet shrub types other than S1 and S7. A plot illustrating C4 on wet Montane fluvial terrain of both the VL3 and VL4 Ecosites is described in the VL4 Ecosite description (Table 371).

Discussion

The VL3 Ecosite encompasses wet floodplains dominated by forest and shrub vegetation in the Montane Ecoregion. It resembles the

Hector 1 (HC1) Ecosite which is its Lower Subalpine counterpart. The HC1 Ecosite, however, is more complex, representing a greater range of drainage regimes, and has vegetation reflecting the Lower Subalpine environment. Vegetation differences, in the main, distinguish VL3 from the other VL Ecosites (Table 366).

VL4 - VERMILION LAKES 4 ECOSITE

Ecosite Concept

The Montane Ecosite, VL4, encompasses wet, level floodplains, aprons, and fans dominated by forest vegetation. These landforms consist of calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) and the coarse fragment free phase of calcareous, coarse, stratified fluvial material (Fluvial material B). The floodplain surfaces are often eroded (channelled) with slightly elevated, gently sloping levees bordering the channels.

Imperfectly to poorly drained Rego Gleysols, usually with surface peat layers, are dominant. Vegetation of VL4 is dominated by the white spruce/prickly rose/horsetail (C4) v.t.

Geomorphology

The VL4 Ecosite is typified by gently sloping landforms consisting of calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) and the low coarse fragment content phase of calcareous, coarse, stratified fluvial material (Fluvial material B). The fluviolacustrine material indicates deposition by siltation from silt-laden glacial meltwater in backwater localities. The fluvial material infers deposition from quiet water in and adjacent to the numerous distributary channels. Interlayering of the two deposits demonstrates the dynamics of depositional environments over time across the landscape. Presence of thin organic layers, incorporated in the mineral deposits and mantling the surface, indicate periods of little or no sedimentation. Most VL4 soils have thin surface layers of moderately decomposed peat derived from moss, sedge, and forest sources. The VL4 Ecosite is not extensively ponded like VL1, nor is it flooded as frequently as VL3. Wetness is due to high, fluctuating water tables.

Topographically, VL4 dislays gentle linear slopes on level floodplains and the toes of aprons and fans. The floodplains are composed of fluviolacustrine and fluvial deposits; the fans and aprons are dominated by fluvial deposits although these are sometimes capped by fluviolacustrine veneers. Slopes commonly range from 0 to 2%. Slope continuity is often broken by numerous abandoned and active, distributary stream channels meandering across the landscape (Eroded modifier, C.S.S.C. 1978b). These are more common on the level floodplains. Gently sloping, slightly elevated levees border the channels. Weakly expressed terracing (risers <1 m) is another minor feature on some floodplain tracts.

Soils

Imperfectly to poorly drained Rego Gleysols dominate the VL4 Ecosite. Prolonged periods of saturation (high water tables) plus recent sedimentation have inhibited pedogenic development other than gleization. Thin peat layers occur at the surface on most VL4 soils, their presence governed by the amount of fluvial and fluviolacustrine deposition in recent times. Gleyed Cumulic Regosols are accessory soils and are associated with imperfectly drained sites where the water table strongly affects only lower portions of the control section. Such sites include the natural levees and tract fringes. On portions of some tracts (e.g. the lower part of Healy Creek fan), Gleyed Cumulic Regosols are quite common, to the point of dominance or codominance indicating that drainage conditions are slightly drier than normal for VL4. Humic Gleysols and other gleyed Regosolic soils occur in minor amounts. A pedon illustrating Rego Gleysols of VL4 is described in Table 370 and shown in Color Plate 80.

Vegetation

The VL4 Ecosite is dominated by the white spruce/prickly rose/horsetail (C4) v.t. This reflects wet conditions, namely high water tables, and occasional flooding but with little or no sediment deposition. Balsam poplar/horsetail (C28) and white spruce/shrubby cinquefoil/bearberry (O3) occur as accessory v.t.s. The C28 v.t. occurs primarily on actively aggrading, elevated, imperfectly drained, natural levees along major stream channels. The O3 v.t. occurs on imperfectly drained, non-aggrading sites with relatively dry surface conditions. Engelmann spruce/horsetail/feathermoss (C32) and spruce/arrow-grass-sedge (O7) occur in minor amounts. A plot representing vegetation of the pedon sample site (Table 370) and illustrating C4 on VL4 is presented in Table 371 and Plate 9.

Discussion

The VL4 Ecosite encompasses wet floodplains, fans, and aprons dominated by forest in the Montane Ecoregion. It resembles the Hector 1 (HC1) Ecosite which is its Lower Subalpine counterpart. However, HC1 is more complex, representing a greater range of drainage regimes, and has a pattern of forest $>$ shrub vegetation reflecting this complexity

Table 370 Pedon (Alberta 1978 No. 30) description of a Rego Gleysol of the VL4 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: REGO GLEYSOL. SOIL MAP UNIT: NOTATION: VL4.

LOCATION: MILITARY GRID REF. 11 UNJ 2925 8035; NTS MAP AREA 83E 1E.

CLIMATE: 1000 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS MODERATE RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 8 DEG(C) AT 20 CM IN SEPTEMBER, NO. 2 WAS 7 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JN8119*VTN=C4*.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), FLUVIAL; LANDFORM CLASSIFICATION: FLUVIAL, LEVEL; SLOPE: 0.5% SIMPLE SLOPE OF CLASS 1 (0-0.5%), FACING LEVEL, SITE AT DEPRESSION POSITION; SOIL MOISTURE AND DRAINAGE: POORLY DRAINED, SLOWLY PERVIOUS, SLOW SURFACE RUNOFF, SEEPAGE PRESENT.

SPECIAL NOTES: SSN=DA8100*APN=015-137*AHK NOT SAMPLED*LFH=FL*

OF: 24 TO 14 CM, RANGE 9 TO 20 CM; HORIZON MOIST; MATRIX MOIST 5YR 2.5/2; PLENTIFUL, VERY FINE AND FINE AND MEDIUM AND COARSE, HORIZONTAL ROOTS; VERY STRONGLY CALCAREOUS; WAVY, GRADUAL HORIZON BOUNDARY.

OH: 14 TO 0 CM, RANGE 8 TO 14 CM; HORIZON MOIST; MATRIX MOIST 5YR 3/2; PLENTIFUL, VERY FINE AND FINE AND MEDIUM AND COARSE, HORIZONTAL ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CKG1: 0 TO 8 CM, RANGE 8 TO 10 CM; HORIZON MOIST; MATRIX MOIST 2.5Y 4/8; VERY FINE SANDY LOAM; FEW, COARSE, PROMINENT MOTTLES; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE AND FINE AND MEDIUM, HORIZONTAL ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CKG2: 8 TO 20 CM, RANGE 10 TO 14 CM; HORIZON MOIST; MATRIX MOIST 2.5Y 6/2; SILT LOAM; MANY, COARSE, PROMINENT, 5YR 5/8 MOTTLES; VERY WEAK, FINE, PLATY STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE AND FINE AND MEDIUM, RANDOM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, GRADUAL HORIZON BOUNDARY.

AHKGB: 20 TO 23 CM, RANGE 2 TO 8 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/2; SILT LOAM; MANY, MEDIUM, PROMINENT, 10YR 5/6 MOTTLES; WEAK, FINE, PLATY STRUCTURE; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE AND FINE AND MEDIUM, RANDOM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

CKG3: 23 TO 56 CM; HORIZON MOIST; MATRIX MOIST 2.5Y 6/2; SILT LOAM; MANY, COARSE, PROMINENT, 10YR 5/6 MOTTLES; VERY WEAK, VERY FINE TO FINE, PLATY STRUCTURE; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, VERY FINE AND FINE AND MEDIUM, RANDOM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
OF	7.4	16.50	37.4
OH	7.3	17.30	41.2
CKG1	7.6		54.1
CKG2	7.6	0.20	50.8
AHKGB			
CKG3	7.6		54.1

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS													
	% PASSING										% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
OF														
OH														
CKG1	99	99	99	99		1	4	37	24	66		28	6	
CKG2						0	3	14	20	37		54	9	
AHKGB														
CKG3	99	99	99	99		0	0	4	26	30		66	4	

PHYSICAL DATA

	MOISTURE STATUS (%)					ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST								
OF													
OH												A-8	OH
CKG1		3.4	1.2										
CKG2													
AHKGB													
CKG3		6.5	1.4									A-8	PT

in the Lower Subalpine environment. The Hillsdale 2 and 3 (HD2, HD3) Ecosites are marginally similar to VL4 but are dominated by soils and vegetation reflecting significantly drier conditions. Vegetation differences, in the main, distinguish VL4 from the other VL Ecosites (Table 366).

VL5 - VERMILION LAKES 5 ECOSITE

Ecosite Concept

The Montane VL5 Ecosite encompasses wet level floodplains, aprons, and fans dominated by shrub vegetation. These landforms consist

Table 371 Stand (JM8119) illustrating the white spruce/prickly rose/horsetail (C4) v.t. of the VL3 and VL4 Ecosites.

TREE LAYER	
Picea glauca	39
Populus balsamifera	01
Salix bebbiana	03
TALL SHRUB LAYER	
Picea glauca	.5
Salix bebbiana	.5
SHRUB LAYER	
Cornus stolonifera	01
Lonicera dioica	.5
Lonicera involucrata	.5
Picea glauca	.5
Rosa acicularis	01
Shepherdia canadensis	.5
HERB-DWARF SHRUB LAYER	
Actaea rubra	.5
Aster ciliolatus	.5
Carex concinna	.5
Disporum trachycarpum	.5
Fragaria virginiana	.5
Linnaea borealis	01
Pyrola asarifolia	.5
Pyrola secunda	01
Pyrola virens	.5
Rubus pubescens	.5
Viola renifolia	.5
Equisetum arvense	67
BRYOID LAYER	
Barbula icmadophila	.5
Brachythecium spp.	.5
Ceratodon purpureus	.5
Ditrichum flexicaule	.5
Hypnum cupressiforme	.5
Isopterygium pulchellum	.5
Orthotrichum obtusifolium	.5
Peltigera canina	01
Pylaisiella polyantha	.5
Thuidium abietinum	65
Tortula ruralis	.5
EPIPHYTES	
Parmelia sulcata	.5
Parmeliopsis hyperopta	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

of calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) and the coarse fragment free phase of calcareous, coarse, stratified fluvial material (Fluvial material B). The floodplain surfaces are often eroded (channeled) with slightly elevated, gently sloping levees bordering the channels.

The imperfectly to poorly drained soils are characterized by a pattern in which Rego Gleysols are dominant and Gleyed Cumulic Regosols are subdominant. Vegetation is dominated by the willow/horsetail (S7) v.t. that reflects occasional periods of sediment deposition. The VL5 Ecosite occurs only in Jasper on the actively aggrading floodplains, aprons, and fans in the Athabasca and Miette River valleys.

Geomorphology

The VL5 Ecosite is typified by gently sloping landforms consisting of calcareous, fine, stratified fluviolacustrine material (Fluviolacustrine material B) and the coarse fragment free phase of calcareous, coarse, stratified fluvial material (Fluvial material B). A low lime variant of Fluvial material B, also with few coarse fragments, dominates a few tracts in western Jasper, particularly in the Miette and Athabasca River valleys east and north to Jasper townsite. Altered, fine, stratified fluviolacustrine material (Fluviolacustrine material A) occurs as veneers on some of the benchland VL5 tracts. These often occupy the toes of aprons and fans (e.g. the VL5 tract at Pyramid Lake). The fluviolacustrine material indicates deposition by siltation from silt-laden glacial meltwater in backwater localities. The fluvial material infers deposition from quiet water in and adjacent to the numerous distributary channels. Interlayering of the two deposits demonstrates the dynamics of depositional environments over time across the landscape. Presence of thin organic layers, incorporated in the mineral deposits and mantling the suface, indicate periods of little or no sedimentation. The VL5 Ecosite is not extensively ponded like VL1, but sediment deposition associated with episodic flooding occurs frequently, resulting in discontinuous surface peat layers.

Topographically, VL5 displays gentle linear slopes on level floodplains and the toes of aprons and fans. The floodplains are composed of fluviolacustrine and fluvial deposits; the fans and aprons are dominated by fluvial deposits although these are sometimes overlain by fluviolacustrine veneers. Slopes commonly range from 0 to 2%. Slope continuity is often broken by numerous abandoned and active distributary stream channels meandering across the landscape (Eroded modifier, C.S.S.C. 1978b). These are more common on the level floodplains. Gently sloping, slightly elevated levees border the channels. Weakly expressed terracing (risers <1 m) is another minor feature on some floodplain tracts.

Soils

A soil pattern reflecting drainage conditions and depth to the fluctuating water table characterizes VL5. Rego Gleysols are dominant and display strong gleying in the upper part of the control section. Gleyed Cumulic Regosols are subdominant and occur on localities where average depths to the water table are greater. These localities include natural levees and tract fringes. Due to the episodic but frequent sediment deposition on VL5, its imperfectly to poorly drained soils lack or have very thin, surface, peat layers. Sedimentation plus prolonged periods of

Table 372 Pedon (Alberta 1978 No. 31) description of a Rego Gleysol cf the VL5 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: REGO GLEYSOL. SOIL MAP UNIT: NOTATION: VL5.

LOCATION: MILITARY GRID REF. 11 UNU 2835 7925; NTS MAP AREA 83E 1E.

CLIMATE: 1000 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER SOIL TEMP READING NO. 1 WAS 7 DEG(C) AT 20 CM IN SEPTEMBER, NO. 2 WAS 7 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=SJ8105*VTH=97*.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), FLUVIOLACUSTRINE; LANDFORM CLASSIFICATION: FLUVIAL AND LACUSTRINE, LEVEL; SLOPE: 0.5% SIMPLE SLOPE OF CLASS 1 (0-0.5%), FACING LEVEL, SITE AT MIDDLE POSITION, MODERATELY MOUNDED MICROTOPOGRAPHY,; SOIL MOISTURE AND DRAINAGE: POORLY DRAINED, SLOWLY PERVIOUS, SLOW SURFACE RUNOFF, SEEPAGE PRESENT; NONSTONY; NO*ROCKY.

SPECIAL NOTES: SSN=DA8101*APN=015-137*CK AND FB NOT SAMPLED*SOIL PROFILE FRAGMENT FREE*LFH=FLL*

LF: 5 TO 0 CM, RANGE 4 TO 8 CM; HORIZON MOIST; MATRIX MOIST 5YR 3/2; ABUNDANT, VERY FINE AND FINE, HORIZONTAL ROOTS; STRONGLY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CK: 0 TO 1 CM, RANGE 0 TO 2 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/2; SILT LOAM; WEAK TO MODERATE, FINE, PLATY STRUCTURE PSEUDO; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE, HORIZONTAL ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; BROKEN, ABRUPT HORIZON BOUNDARY.

FB: 1 TO 4 CM, RANGE 0 TO 4 CM; HORIZON MOIST; MATRIX MOIST 5YR 3/2; ABUNDANT, VERY FINE AND FINE, HORIZONTAL ROOTS; BROKEN, CLEAR HORIZON BOUNDARY.

CKGJ: 4 TO 12 CM, RANGE 4 TO 12 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/3; SILT LOAM; FEW, MEDIUM, DISTINCT, 7.5YR AND 10YR 5/6 AND 5/4 MOTTLES; WEAK, FINE, PLATY STRUCTURE PSEUDO AND STRATIFIED; WEAK, FINE, GRANULAR SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE AND FINE, RANDOM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CKG1: 12 TO 24 CM, RANGE 10 TO 14 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/2; SILT LOAM; MANY, COARSE, PROMINENT, 7.5YR 5/6 MOTTLES; WEAK, FINE, PLATY STRUCTURE PSEUDO AND STRATIFIED; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE, RANDOM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

AHKGB: 24 TO 30 CM, RANGE 4 TO 8 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/2, MATRIX MOIST 7.5YR 3/2; SILTY CLAY LOAM; MANY, FINE, PROMINENT, 2.5YR AND 5YR 4/8 AND 5/8 MOTTLES; WEAK TO MODERATE, FINE TO MEDIUM, PLATY STRUCTURE PSEUDO AND STRATIFIED; WEAK, FINE TO MEDIUM, GRANULAR SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, VERY FINE, RANDOM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CKG2: 30 TO 36 CM, RANGE 5 TO 8 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/2; SILT; MANY, COARSE, PROMINENT, 10YR 5/8 MOTTLES; WEAK TO MODERATE, FINE TO MEDIUM, PLATY STRUCTURE PSEUDO AND STRATIFIED; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, VERY FINE, RANDOM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; SMOOTH, ABRUPT HORIZON BOUNDARY.

CKG3: 36 TO 43 CM, RANGE 5 TO 10 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/2; SILT LOAM; MANY, FINE, PROMINENT, 5YR 5/8 MOTTLES; MANY, FINE, PROMINENT, 10YR 5/8 MOTTLES; WEAK TO MODERATE, FINE, PLATY STRUCTURE PSEUDO AND STRATIFIED; WEAK TO MODERATE, FINE TO MEDIUM, GRANULAR SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, VERY FINE, RANDOM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, ABRUPT HORIZON BOUNDARY.

CKG4: 43 TO 57 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/2; SILT LOAM; MANY, COARSE, PROMINENT, 5YR 5/8 MOTTLES; MANY, COARSE, PROMINENT, 10YR 5/8 MOTTLES; WEAK TO MODERATE, FINE, PLATY STRUCTURE PSEUDO AND STRATIFIED; STRUCTURELESS, SINGLE GRAIN SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS													
	% PASSING										% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
CK														
FB														
CKGJ										1		77	22	
CKG1										41		55	4	
AHKGB										1		62	37	
CKG2										6		89	5	
CKG3		99	99	99	99					2		75	23	
CKG4		99	99	99	99					22		72	6	

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LF	7.0	28.90	15.8
CK			
FB			
CKGJ	7.2	2.50	58.4
CKG1	7.3	0.00	50.8
AHKGB	7.4	2.00	61.5
CKG2	7.6	0.50	55.0
CKG3	7.5	1.20	62.0
CKG4	7.7	0.00	57.0

PHYSICAL DATA

	MOISTURE STATUS (%)					ENGINEERING							
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
CK													
FB													
CKGJ													
CKG1		5.4	1.3										
AHKGB													
CKG2												48	89
CKG3		31.0	6.3			26.0	34.0					48	10
CKG4		6.3	1.7										

saturation inhibit pedogenic horizonation other than strong gleization. Humic Gleysols and other gleyed Regosolic soils occur in minor amounts. A pedon illustrating Rego Gleysols of VL5 is described in Table 372 and shown in Color Plate 81. Surface organic accumulation on this profile indicates that sediment deposition has not occurred on this site in the last few years.

Vegetation

The VL5 Ecosite is dominated by the willow/horsetail (S7) v.t. This type reflects wet conditions and episodic sediment deposition. Balsam poplar/horsetail (C28) and dwarf birch-shrubby cinquefoil-willow/brown moss (S1) occur as accessory v.t.s. The C28 v.t. occurs mostly on actively aggrading, elevated, imperfectly drained, natural levees along major stream channels, whereas S1 is associated with localities where sedimentation is infrequent or has ceased. Related soils have abnormally well developed organic layers at their surfaces. On some VL5 tracts of benchland positions, S1 is quite common. Other moist to wet shrub types, water sedge-beaked sedge (H11), and sedge-saxifrage (H3) occur in minor amounts. A stand representing vegetation of the pedon sample site (Table 372) and illustrating S7 on VL5 is presented in Table 373 and Plate 55. The well developed shrub layer and high species diversity of the stand indicate that sediment deposition on the site has not occurred during the last few years.

Discussion

The VL5 Ecosite encompasses wet floodplains, fans, and aprons dominated by shrub vegetation in the Montane Ecoregion. It resembles the Hector 4 (HC4) and Num-Ti-Jah 2 (NT2) Ecosites which are its Lower Subalpine and Upper Subalpine counterparts respectively. However, soils and vegetation of HC4 and NT2 reflect more stable geomorphic conditions (little or no sedimentation) and the Lower Subalpine and Upper Subalpine environments. Vegetational differences, in general, distinguish VL5 from the other VL Ecosites (Table 366).

WF - WILDFLOWER ECOSECTION

The Wildflower (WF) Ecosection encompasses steep, linear landforms comprised of calcareous, medium textured colluvium (Colluvium C) in the Upper Subalpine portion of the Subalpine Ecoregion. It occurs on or below steep valley walls and is associated with calcareous strata. Varying type and degree of colluvial activity, aspect, exposure, and lithology govern soil and vegetation development and distribution. The WF Ecosection is characterized by Brunisolic and Regosolic soils associated with avalanche complex vegetation, Engelmann spruce-subalpine fir open and closed forests, Engelmann spruce forest, mixed coniferous open forest, grassland, shrub thicket, and grassy tundra.

Table 373 Stand (SJ8105) illustrating the willow/horsetail (S7) v.t. of the VL5 Ecosite.

TREE LAYER	
Picea glauca	.5
TALL SHRUB LAYER	
Picea glauca	.5
Salix bebbiana	14
SHRUB LAYER	
Cornus stolonifera	02
Lonicera dioica	25
Ribes spp.	01
Rosa acicularis	15
Rubus strigosus	10
HERB-DWARF SHRUB LAYER	
Achillea millefolium	02
Arabis hirsuta	.5
Artemisia michauxiana	03
Aster ciliolatus	01
Calamagrostis canadensis	.5
Epilobium angustifolium	01
Galeopsis tetrahit	01
Phleum pratense	25
Ranunculus acris	01
Smilacina stellata	01
Taraxacum officinale	.5
Urtica spp.	25
Vicia americana	06
Equisetum arvense	01
BRYOID LAYER	
Amblystegium serpens	.5
Orthotrichum obtusifolium	.5
Physcia adscendens	.5
Physcia orbicularis	.5
Physcia spp.	.5
Pylaisiella polyantha	.5
Thuidium abietinum	.5
Tortula ruralis	.5
EPIPHYTES	
Caloplaca cerina	.5
Caloplaca holocarpa	.5
Candellariella aurella	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Five Ecosites (WF1, WF2, WF3, WF4, WF7) are recognized within the WF Ecosection and are separated primarily on vegetational differences. Table 374 outlines the general features of the WF Ecosites. Figure 51 for the Sawback (SB) Ecosection shows the WF1 and WF2 Ecosites on the landscape in relation to other Ecosites. Figure 52 for the Snowflake (SF) Ecosection shows WF7 on the landscape.

WF1 - WILDFLOWER 1 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, WF1, encompasses blankets and veneers comprised of cal-

Table 374 General features of the Wildflower (WF) Ecosites.

Ecosite	Landform	Soils	Vegetation
WF1	Colluvium C; blanket, veneer	Brunisolic, Regosolic	Engelmann spruce-subalpine fir open and closed forests
WF2	Colluvium C; blanket, veneer, apron	Brunisolic, Regosolic	Avalanche Complex 2 > Engelmann spruce-subalpine fir open and closed forests
WF3	Colluvium C; blanket, veneer > bedrock; inclined	Brunisolic, Regosolic	mixed coniferous open forest > Engelmann spruce-subalpine fir open forest
WF4	Colluvium C; blanket, veneer	Brunisolic, Regosolic	Engelmann spruce forest
WF7	Colluvium B,C; blanket, veneer	Brunisolic, Regosolic	grassland, shrub thicket, grassy tundra

careous, medium textured colluvium (Colluvium C) overlying inclined bedrock on steep valley walls. The WF1 Ecosite is dominated by Orthic and Eluviated Eutric Brunisols and Orthic Regosols. Orthic Eutric Brunisols are most abundant. Vegetation is dominated by the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/heather (O10), and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s. The C15 and O10 v.t.s are most abundant.

Geomorphology

The WF1 Ecosite encompasses blankets and veneers comprised of calcareous, medium textured colluvium (Colluvium C) overlying inclined bedrock on steep valley walls. Source bedrock is predominantly calcareous. Veneers of altered, medium textured eolian material (Eolian material B) may occur sporadically on stable WF1 tracts in western Banff and southwestern Jasper. Erosional and colluvial processes have removed or incorporated much of the wind blown accumulations. Till occasionally underlies colluvial material along lower, more gentle slopes of WF1 tracts. Thin, generally calcareous, coarse, stratified fluvial material (Fluvial material B), occasionally overlies colluvium on avalanched portions of WF1A tracts.

Topographically, WF1 displays long, linear slopes commonly ranging from 45 to 90%. Tracts mapped as WF1 with complex topography exhibit linear colluvial slopes whose continuity is broken by one or more rock escarpments. Bedrock outcrops are common on WF1+R tracts. Surface form is controlled by deposition and underlying bedrock. Colluvial material is generally shallowest (veneers) at the tops of slopes and deepest downslope. Colluvial aprons occur occasionally along slope bases at major slope breaks. Colluvial veneers dominate WF1X tracts.

Soils

The soils of the WF1 Ecosite reflect relatively stable geomorphic conditions. Well to moderately well drained Orthic and Eluviated Eutric Brunisols and Orthic Regosols are the dominant soils. Orthic Eutric Brunisols are most abundant and occupy portions where slight surface modification is regular and sufficient to retard or destroy eluvial (Ae) horizon development. Eluviated Eutric Brunisols and Orthic Regosols dominate a few tracts. Orthic Regosols and accessory Cumulic Regosols occur on portions of tracts that are strongly modified by erosional and colluvial processes. Where geomorphic activity is least frequent or intense and veneers of altered, medium textured eolian material (Eolian material B) are present, Eluviated Eutric Brunisols and accessory Orthic Humo-Ferric Podzols occur. Lithic soil phases dominate tracts mapped as WF1X. A pedon illustrating Orthic Eutric Brunisols of the WF1 Ecosite is described in Table 375 and shown in Color Plate 82. This pedon was sampled above Sundance Pass in the Sundance Range in Banff.

Vegetation

The Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/heather (O10) and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s are dominant in WF1. The C15 and O10 v.t.s are most abundant. A few WF1 tracts are dominated by the C21 v.t. The O10 v.t. occurs above the C15 and C21 v.t.s and is most extensive on northerly aspects. The subalpine larch-subalpine fir/grouseberry-everlasting (C23) is an important accessory v.t. occurring on several WF1 tracts in Banff south of Hector Lake and Pipestone Pass. Many tracts have up to 50% of their area occupied by avalanche paths. Areas with 20

Table 375 Pedon (Alberta 1978 No. 75) description of an Orthic Eutric Brunisol of the WF1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT NOTATION: WF1.

LOCATION: MILITARY GRID REF. 11 UPG 120 5860; NTS MAP AREA 82O 4E.

CLIMATE: 2160 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP REALTNS NO. 1 HAS 2 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VPN=JC8090=VTN=CE1=.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EOLIAN, SEDIMENTARY; PARENT MATERIAL 2: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), COLLUVIAL, SEDIMENTARY; SLOPE: 65% SLOPE OF CLASS 8 (46-70%), FACING NORTHEAST, SITE AT UPPER SLOPE POSITION, SLIGHTLY ROUNDED MICROTOPOGRAPHY,150 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; SLIGHTLY STONY; NONROCKY.

SPECIAL NOTES: SSN=NT815=APN=011-012=RLU=18=PCF=16R(2-3)=AB,3GR,2AC,1CB(4)3AG,1GR,2AC(3)SAB,3AC(6)=LFH=CB/RZ=

LF: -8 TO 0 CM, RANGE 6 TO 8 CM; MATRIX MOIST 5YR 3/2; PLENTIFUL, VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AE: 0 TO 1 CM, RANGE 0 TO 2 CM; MATRIX MOIST 10YR 6/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE AND MEDIUM AND COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BM: 1 TO 20 CM, RANGE 17 TO 22 CM; MATRIX MOIST 7.5YR 5/8, MATRIX MOIST 5YR 5/6; SILT LOAM; VERY WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; FRIABLE CONSISTENCE; FEW, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

2BCK: 20 TO 43 CM, RANGE 22 TO 25 CM; MATRIX MOIST 10YR 5/3; GRAVELLY FINE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, FINE AND MEDIUM ROOTS; STRONG EFFERVESCENCE, EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

2CK1: 43 TO 77 CM, RANGE 32 TO 38 CM; MATRIX MOIST 10YR 6/3; VERY FINE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

2CK2: 77 TO 95 CM; MATRIX MOIST 10YR 6/3; GRAVELLY FINE SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; FRIABLE CONSISTENCE; VERY FEW, VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	5.9	44.90							
AE									
BM	5.8	3.20	1.1	22.0		7.7	2.1	0.1	0.1
2BCK	7.1		97.1						
2CK1	7.0		84.4						
2CK2	7.3		97.2						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM	0.1		0.2	
2BCK				
2CK1				
2CK2				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	% OF SAMPLE 50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE														
BM					1	2	3	9	11	22		66	12	
2BCK					1	1	4	28	22	56		40	4	
2CK1					4	3	4	17	20	48		46	6	
2CK2		99	78	31	22	12	8	7	19	15	61		36	3

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE													
BM		40.8	16.1										
2BCK													
2CK1		10.5	2.1										
2CK2		7.6	1.3									11	02

to 50% of their landscape affected by snow avalanching are mapped as WF1A and contain avalanche v.t.s such as subalpine fir-willow (S2). A stand illustrating the Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t. of the WF1 Ecosite is described in Table 376 and shown in Plate 178. It represents vegetation at the pedon sample site described in Table 375.

Table 376 Stand (JC8090) illustrating the Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t. of the WF1 Ecosite.

TREE LAYER	
Abies lasiocarpa	07
Larix lyallii	03
Picea engelmannii	10
Pinus albicaulis	05
TALL SHRUB LAYER	
Abies lasiocarpa	04
Picea engelmannii	01
SHRUB LAYER	
Abies lasiocarpa	08
Picea engelmannii	02
Rhododendron albiflorum	25
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	01
Arnica cordifolia	.5
Phyllodoce glanduliflora	05
Vaccinium membranaceum	01
Vaccinium myrtillus	03
Vaccinium scoparium	15
BRYOID LAYER	
Cladonia cenotea	.5
Cladonia gonecha	.5
Cladonia lepidota	.5
Dicranum fuscescens	02
Dicranum scoparium	03
Drepanocladus uncinatus	01
Hylocomium splendens	55
Peltigera aphthosa	.5
Pleurozium schreberi	20
Pohlia nutans	01
Timmia austriaca	01
Barbilophozia hatcheri	01
Blepharostoma tricophyllum	01
Lophozia spp.	.5
EPIPHYTES	
Bryoria fuscescens	.5
Hypogymnia austerodes	.5
Letharia vulpina	.5
Usnea sorediifera	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The WF1 Ecosite is one of the least extensive of the Wildflower Ecosites and occurs more in Banff than in Jasper. In terms of landform surface expression, physiographic position, and vegetation cover, WF1 resembles the Endless Chain 1 (EN1) and Whitehorn 2 (WH2) Ecosites. However, rather than the Colluvium C of WF1, EN1 occurs on colluvial landforms consisting of noncalcareous, coarse textured colluvium (Colluvium A) and WH2 occurs on noncalcareous, medium textured colluvium (Colluvium B). Also, both EN1 and WH2 have Dystric rather than Eutric Brunisols. The other Wildflower Ecosites are differentiated from WF1 primarily by vegetation differences as outlined in Table 374. The Sawback 2 (SB2) Ecosite is the Lower Subalpine counterpart to WF1.

WF2 - WILDFLOWER 2 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, WF2, encompasses blankets and veneers comprised of calcareous, medium textured colluvium (Colluvium C) that mantle inclined bedrock on steep valley walls and form aprons along slope bases at major slope breaks. Snow avalanching is characteristic and governs the distribution of vegetation and, to a lesser extent, soils. Soils are dominated by Orthic Eutric Brunisols, Orthic Regosols and Orthic and Cumulic Humic Regosols. Avalanched segments are dominant and occur most commonly as coalescing unconfined avalanche tracks. They are characterized by a heterogeneous complex of v.t.s that include subalpine fir-willow (S2), willow-dwarf birch-shrubby cinquefoil (S10), juniper-willow (L2), hairy wild rye-wild strawberry-fireweed (H5), fleabane-valerian (H16), plus intergrades, collectively called Avalanche Complex 2. Forested strips and patches between avalanche tracks and fringing runout zones are subdominant and best represented by the Engelmann spruce-subalpine fir/grouseberry (C15) and Engelmann spruce-subalpine fir/heather (O10) v.t.s.

Geomorphology

The WF2 Ecosite encompasses blankets, veneers and aprons comprised of calcareous, medium textured colluvium (Colluvium C). Source bedrock is predominantly calcareous. More than 50% of WF2 is modified by snow avalanching. Avalanching of such areal extent usually occurs with coalescing unconfined avalanche paths, or as runout zones below the length of a cliff. Gully-like channeled avalanche tracks (chutes) are common as well. Perla and Martinelli (1975) define snow avalanche zone terminology.

Genetic material stability within WF2 tracts is greatest on portions unaffected by avalanching, but the unconfined tracks are

almost as stable. Together these components make up the majority of the area of WF2 tracts. Instability is of two kinds. Erosion of unconsolidated material occurs, though infrequently, on steep avalanche starting zones and on walls of channeled tracks. It is usually evidenced by sparsely vegetated patches. Deposition is a more common process, and frequently includes material derived from bedrock exposures high on or above the WF2 tract. Material carried by avalanching is distributed downslope in gentler runout zones. Colluvial material is modified by intermittent streams below couloirs and on avalanche runout zones. Fluvial deposits, occurring as thin veneers and as layers interbedded with colluvium, are most abundant below channeled tracks and couloirs. This fluvial material is a weakly sorted variant of Fluvial material B and, like the colluvium, is medium textured with a high content of angular coarse fragments. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically on the subdominant unavalanched segment of the landscape. Rubble that lacks fine earth material for soil development is common on some WF2 tracts, particularly those occurring below steep rock walls.

Topographically, WF2 displays, long, linear inclined slopes commonly ranging from 45 to 90%. Slopes <45% occur on avalanche runout zones on gentler lower slopes and on toes of colluvial aprons. Surface form is controlled by deposition and underlying bedrock. The colluvial material is generally shallowest (veneers) at the tops of slopes and deepens downslope to form aprons along slope bases at abrupt topographic changes. Colluvial aprons also occur below rock walls. Fans constructed by intermittent streams, are often associated with minor gullying upslope on avalanche tracts. Colluvial veneers dominate on WF2X tracts.

Soils

Soil distribution and development on the WF2 Ecosite is related to genetic material stability as influenced by avalanching and supplementary processes. A variety of soils, best represented by the Orthic Eutric Brunisol, Orthic Regosol, Orthic Humic Regosol, and Cumulic Humic Regosol Subgroups, reflect varying degrees of colluvial and fluvial activity and organic matter incorporation. Orthic Eutric Brunisols occupy portions of the landscape where surface modification is weak but sufficient to retard or destroy eluvial (Ae) horizon development. On localities where geomorphic activity, either removal or accretion, is frequent and intense, Orthic Regosols and Orthic and Cumulic Humic Regosols are abundant. These localities are predominantly avalanche track centers. Orthic Regosols also occur on unvegetated rubbly sites.

Soils of WF2 are rapidly to moderately well drained and reflect, in their development, the calcareous, medium textured parent material. Orthic Eutric Brunisols have thin sola and weakly developed Bm or Bmk horizons. Orthic and Cumulic Humic Regosols have thick (>10cm) Ah horizons that have built up by a combination of organic matter incorporation to the surface and physical accretion. Orthic Regosols usually have Ah horizons of various thicknesses up to 10cm. Orthic Melanic Brunisols and Cumulic Regosols are important accessory soils that also occur on avalanched segments. Eluviated Eutric Brunisols occur in minor amounts on forested segments and may be associated with the altered, medium textured eolian material (Eolian material B). A pedon illustrating Cumulic Humic Regosols of the WF2 Ecosite is described in Table 377 and shown in Color Plate 83. This pedon was sampled in the upper Pipestone River valley in Banff.

Vegetation

Vegetation distribution on the WF2 Ecosite is governed by the frequency and intensity of snow avalanching. Avalanched segments dominate and are characterized by a heterogeneous complex of avalanche v.t.s including subalpine fir-willow (S2), willow-dwarf birch-shrubby cinquefoil (S10), juniper-willow (L2), hairy wild rye-wild strawberry-fireweed (H5), fleabane-valerian (H16), plus intergrades. The S2 v.t. is the most abundant and extensive on WF2. The accessory v.t. willow/cinquefoil (S8) and small amounts of the willow-dwarf birch/fleabane (S4) v.t. also occur on avalanche paths. Near the Upper Subalpine-Alpine boundary, minor amounts of the mountain avens-snow willow-moss campion (H1) and heather-everlasting (L5) v.t.s occur. A plot representing the subalpine fir-willow (S2) v.t. on the avalanched segment of WF2 is described in Table 378 and shown in Plate 179. Unavalanched or infrequently avalanched segments may constitute up to 50% of WF2 tracts and occur as forested strips between avalanche paths and as patches along lower slopes and toes adjacent to avalanche runout zones. The Engelmann spruce-subalpine fir/grouseberry (C15) and Engelmann spruce-subalpine fir/heather (O10) v.t.s are most abundant on these segments. Engelmann spruce-subalpine fir/rock willow/alpine bearberry (O12) is an accessory v.t. that occurs on avalanche chute margins. The subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. also occurs occasionally in southern Banff.

Unvegetated portions, associated with rubbly colluvium and Regosolic soils on intensely active sites, constitute up to 50% of WF2 tracts, up to 80% of WF2+T or WF2+CR tracts.

Table 377 Pedon (Alberta 1977 No. 131) description of a Cumulic Humic Regosol of the WF2 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: CUMULIC HUMIC REGOSOL. SOIL MAP UNIT: NOTATION: WF2.

LOCATION: MILITARY GRID REF. 11 UBH 8410 8490; NTS MAP AREA 82N 9E.

CLIMATE 2240 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE.

VEGETATION: VTH=82%.

SOIL SITE: PARENT MATERIAL 1: SHATTERED WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), COLLUVIAL, LIMESTONE; LANDFORM CLASSIFICATION: COLLUVIAL AND UNCONSOLIDATED, AVALANCHED, BLANKET AND INCLINED; SLOPE: 45% SIMPLE SLOPE OF CLASS 8 (46-70%) FACING SOUTHWEST, SITE AT MIDDLE POSITION, LEVEL MICROTOPOGRAPHY,300 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED AND WELL DRAINED, RAPIDLY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; VERY STONY; NONROCKY.

SPECIAL NOTES: SSH=BW7134+APH=810-211+BLM=15+SSC=CB+ST=PCF+6AS,2AC,1FL(2-8)++DOMINANT TEXTURE SIL TO L+LF(1),CK2(6),+BMKB(7)NOT SAMPLED+BMKB FORMS ONE SMALL POCKET+PRIMARY CARBONATE=LFH=CB/RI-A=

LF: 3 TO 0 CM, RANGE 2 TO 4 CM; MANY, FINE PORES; WAVY, ABRUPT HORIZON BOUNDARY.

AMK1: 0 TO 6 CM, RANGE 4 TO 7 CM; MATRIX MOIST 10YR 2/1; VERY GRAVELLY LOAM; WEAK, FINE TO MEDIUM, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE AND MEDIUM, VERTICAL AND HORIZONTAL ROOTS; MANY, FINE PORES; WEAK EFFERVESCENCE; VERY STRONGLY CALCAREOUS; ANGULAR GRAVELLY AND ANGULAR COBBLY AND FLAGGY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

AMK2: 6 TO 16 CM, RANGE 8 TO 11 CM; MATRIX MOIST 10YR 3/2; VERY GRAVELLY VERY FINE SANDY LOAM; VERY WEAK, FINE TO MEDIUM, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, VERY FINE AND FINE AND MEDIUM, VERTICAL AND HORIZONTAL ROOTS; MODERATE EFFERVESCENCE; EXTREMELY CALCAREOUS; ANGULAR GRAVELLY AND ANGULAR COBBLY AND FLAGGY COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

AK1: 16 TO 36 CM, RANGE 18 TO 24 CM; MATRIX MOIST 10YR 5/3; VERY GRAVELLY SANDY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE, VERTICAL ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; ANGULAR GRAVELLY AND ANGULAR COBBLY AND FLAGGY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

AMKB: 36 TO 48 CM, RANGE 8 TO 10 CM; MATRIX MOIST 10YR 3/3, MATRIX MOIST 5YR 3/2; VERY GRAVELLY SILT LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE AND FINE, VERTICAL ROOTS; WEAK EFFERVESCENCE; EXTREMELY CALCAREOUS; ANGULAR GRAVELLY AND ANGULAR COBBLY AND FLAGGY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

CK2: 48 TO 54 CM, RANGE 8 TO 10 CM; MATRIX MOIST 10YR 5/3; VERY GRAVELLY SILT LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE AND FINE, VERTICAL ROOTS; STRONG EFFERVESCENCE; ANGULAR GRAVELLY AND ANGULAR COBBLY AND FLAGGY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BMKB: 54 TO 55 CM, RANGE 0 TO 4 CM; MATRIX MOIST 10YR 3/6; VERY GRAVELLY SILT LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE AND FINE, VERTICAL ROOTS; WEAK EFFERVESCENCE; MODERATELY CALCAREOUS; ANGULAR GRAVELLY AND ANGULAR COBBLY AND FLAGGY COARSE FRAGMENTS; BROKEN, CLEAR HORIZON BOUNDARY.

CK3: 55 TO 95 CM; MATRIX MOIST 10YR 5/3; VERY GRAVELLY SILT LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE AND FINE, VERTICAL ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; ANGULAR GRAVELLY AND ANGULAR COBBLY AND FLAGGY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
LF			
AMK1	6.8	14.90	30.3
AMK2	7.1	3.90	47.7
CK1	7.3	2.00	47.7
AMKB	7.2	2.70	48.8
CK2			
BMKB			
CK3	7.4	2.80	43.9

PHYSICAL DATA

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	ENGINEERING AASHO CLASS	ENGINEERING UNIFIED CLASS
LF								
AMK1								
AMK2								
CK1								
AMKB	48.0	50.0					12	
CK2								
BMKB								
CK3	23.0	28.0					11	17

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AMK1					3	6	8	12	13	42		45	13	4
AMK2					9	8	6	16	17	56		40	4	2
CK1					12	8	5	11	13	49		47	4	3
AMKB					7	5	4	10	12	38		52	10	3
CK2														
BMKB														
CK3	99	66	88	20	6	11	17	11	15	41		53	6	2

Discussion

In terms of landform surface expression, physiographic position and vegetation cover, WF2 resembles the Whitehorn 3 (WH3) and Endless Chain 2 (EN2) Ecosites. However, in contrast to the Colluvium C of WF2, WH3 occurs on colluvial landforms consisting of noncalcareous, medium textured colluvium (Colluvium B) and EN2 occurs on noncalcareous, coarse textured colluvium (Colluvium A). Also, both WH3 and EN2 have Dystric, rather than Eutric, Brunisols. The other WF Ecosites are differentiated from WF2 primarily by vegetation differences as outlined in Table 374. The Sawback 1 (SB1) Ecosite is the Lower Subalpine counterpart to WF2.

Table 378 Stand (JE9178) illustrating the subalpine fir-willow (S2) v.t. of the WF2 Ecosite.

TALL SHRUB LAYER	
Abies lasiocarpa	02
Picea engelmannii	08
SHRUB LAYER	
Abies lasiocarpa	20
Betula glandulosa	12
Juniperus communis	.5
Ledum groenlandicum	01
Picea engelmannii	08
Pinus contorta	.5
Salix barrattiana	05
Salix glauca	03
Salix vestita	08
HERB-DWARF SHRUB LAYER	
Agropyron dasystachyum	.5
Agropyron latiglume	.5
Anemone parviflora	.5
Aquilegia flavescens	.5
Arctostaphylos rubra	02
Artemisia norvegica	.5
Carex scirpoidea	.5
Carex vaginata	01
Cassiope tetragona	04
Empetrum nigrum	10
Erigeron peregrinus	.5
Parnassia fimbriata	.5
Pedicularis bracteosa	.5
Phyllodoce glanduliflora	06
Senecio spp.	.5
Trisetum spicatum	.5
Vaccinium scoparium	15
Zygadenus elegans	.5
Equisetum scirpoides	.5
BRYOID LAYER	
Brachythecium spp.	.5
Candellariella aurella	.5
Cetraria ericetorum	.5
Cladonia coccifera	.5
Cladonia ecmocyna	01
Cladonia gracilis	.5
Cladonia pyxidata	02
Dicranum brevifolium	.5
Dicranum scoparium	03
Drepanocladus uncinatus	02
Grimmia spp.	.5
Orthotricum anomalum	.5
Peltigera aphthosa	01
Peltigera canina	.5
Physcia setosa	.5
Solorina bispora	.5
Timmia austriaca	.5
Toninia candida	.5
Tortella fragilis	.5
Xanthoria elegans	.5
Barbilophozia lycopodioides	05
EPIPHYTES	
Cetraria pinastri	.5
Parmeliopsis ambigua	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

WF3 - WILDFLOWER 3 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, WF3, encompasses blankets and veneers comprised of calcareous, medium textured colluvium (Colluvium C) overlying inclined bedrock on steep valley walls. Exposed bedrock escarpments are subdominant. Colluviation, in the form of surface or soil creep, is characteristic and influences soil and vegetation development. Soils of WF3 are dominated by Orthic Eutric Brunisols, with lesser amounts of Orthic Regosols and Orthic Humic Regosols. A vegetation pattern, in which the Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) v.t. is dominant and the Engelmann spruce-subalpine fir/heather (O10) v.t. is subdominant, is characteristic. Distribution of these v.t.s reflects elevational differences and varying degrees of colluvial activity and moisture status.

Geomorphology

The WF3 Ecosite occurs on shallow, discontinuous colluvial landforms consisting of calcareous, medium textured colluvium (Colluvium C). Exposed bedrock escarpments are subdominant on the landscape. Underlying and exposed bedrock is predominantly calcareous. Geomorphic activity on WF3 primarily consists of shallow colluviation of varying intensity across the landscape. Avalanching and related processes also occur (tracts with 20 to 50% of the landscape affected are mapped as WF3A) but are subdominant. Sheet erosion is extensive but of minor consequence whereas, locally, stream erosion in avalanched couloirs is important to soil and vegetation development. Veneers of altered, medium textured eolian material (Eolian material B) occur sporadically and are associated with stabilized, non-eroding sites. Rubble that lacks fine earth material for soil development is common on some WF3 tracts, particularly those occurring below steep rock walls.

Topographically, WF3 displays long, linear, inclined slopes commonly ranging from 45 to >100%. These slopes consist of discontinuous colluvial veneers and blankets broken by patches of exposed bedrock. Tracts mapped as WF3 with complex topography, have linear slopes whose continuity is broken by one or more exceptionally steep bedrock escarpments and predominantly occur on southerly facing slopes. Tracts mapped as WF3A often have couloirs that act as avalanche paths, and also contain associated stream channels.

Soils

Soil distribution and development characterizing the WF3 Ecosite is governed by the degree and intensity of surface colluviation and, to a lesser extent, avalanching. Rapidly to well drained Orthic Eutric Brunisols, Orthic Regosols, and Orthic Humic Regosols dominate WF3 tracts. Orthic Eutric Brunisols are most abundant and have thin sola and weakly

Table 379 Pedon (Alberta 1979 No. 65) description of an Orthic Eutric Brunisol of the WF3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: WF3.

LOCATION: MILITARY GRID REF. 11 UNJ 6225 3775; NTS MAP AREA 83C 12e.

CLIMATE: 2040 METERS ABOVE MEAN SEA LEVEL. STATION AT JASPER HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 7 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=LC9181=VTN=04=.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), COLLUVIAL, SEDIMENTARY; PARENT MATERIAL 2: RESIDUAL; LANDFORM CLASSIFICATION: ACTIVE COLLUVIAL, VENEER; SLOPE: 70% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING SOUTH, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,400 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; VERY STONY; MODERATELY ROCKY.

SPECIAL NOTES: SSN=UT9159=APN=010-108=RLU=15=PCF=2AB,2AC(1)3AG,2AC(2)5AG,3AC,2ST(3)4AG,3AC(4)4AG,4AC,1ST(5)=LFH=CV/RI-M= DATE=SEPT.17,1979=

L: 2 TO 0 CM, RANGE 0 TO 3 CM; HORIZON DRY; MATRIX DRY 10YR 3.5/2; WAVY, ABRUPT HORIZON BOUNDARY.

BMK: 0 TO 17 CM, RANGE 14 TO 19 CM; HORIZON DRY; MATRIX DRY 10YR 5.5/4, MATRIX MOIST 7.5YR 5/3; SILT LOAM; WEAK TO MODERATE, FINE, SUBANGULAR BLOCKY STRUCTURE; SOFT CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE AND MEDIUM AND COARSE ROOTS; VERY WEAK EFFERVESCENCE, MODERATELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CK1: 17 TO 49 CM, RANGE 28 TO 35 CM; HORIZON DRY; MATRIX DRY 10YR 5/3; GRAVELLY LOAM; WEAK TO MODERATE, FINE, GRANULAR STRUCTURE; LOOSE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; IRREGULAR, CLEAR HORIZON BOUNDARY.

CK2: 49 TO 76 CM, RANGE 25 TO 30 CM; HORIZON DRY; MATRIX DRY 10YR 6/3; GRAVELLY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT CONSISTENCE; FEW, FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CK3: 76 TO 105 CM; MATRIX DRY 10YR 5/2; GRAVELLY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT CONSISTENCE; VERY FEW, FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1 :	ORG C (%)	CALC CARB EQU.%
L	5.2	46.90	
BMK	7.3	4.60	6.4
CK1	7.4		60.6
CK2	7.5		74.0
CK3	7.7		70.0

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2
L				
BMK	0.1		-.1	
CK1				
CK2				
CK3				

PHYSICAL DATA

ENGINEERING

HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
L								
BMK								
CK1								
CK2	20.0	25.0		17.0	1.7		12	17
CK3	21.0	22.0					11	03

PHYSICAL DATA (SURVEY)

PARTICLE SIZE ANALYSIS

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 78-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
L						1	1	3	8	13		72	15	
BMK						12	10	8	4	44		41	15	
CK1					10	10	11	10	6	45		44	11	
CK2	99	63	42	34	8	14	11	9	3	49		42	9	
CK3	99	60	34	27	12									

developed Bm or Bmk horizons. They occupy localities where surface modification is weak but sufficient to retard or destroy Ae horizon development. Orthic Regosols and Orthic Humic Regosols dominate some WF3 tracts. They occupy localities where geomorphic activity, either removal or accretion, is frequent and intense. Accessory Orthic Melanic Brunisols and minor amounts of Cumulic Regosols and Cumulic Humic Regosols also occur on some WF3 tracts. Regosols also occur on unvegetated, rubbly sites and couloirs.

Varying thicknesses of Ah horizons are common to most soils of the WF3 Ecosite. The Ah horizons have built up by a combination of organic matter incorporation to the surface and physical accretion. Accessory Eluviated Eutric Brunisols are an exception to the

above. They occupy localities where geomorphic activity is least frequent or intense and veneers of altered, medium textured eolian material (Eolian material B) occur. Lithic phases of WF3 soils occur frequently. A pedon illustrating Orthic Eutric Brunisols of the WF3 Ecosite is described in Table 379 and shown in Color Plate 84. This pedon was sampled on the east side of Maligne Lake below Samson Peak in Jasper.

Vegetation

Vegetation of the WF3 Ecosite is distributed in a pattern reflecting degree of colluvial activity, drainage and elevation. The Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) v.t. is dominant and occurs on active, subxeric sites on southerly aspects. The Engelmann spruce-subalpine fir/heather (O10) v.t. is subdominant and occurs more extensively at higher elevations and on less active sites. Engelmann spruce-subalpine fir/rock willow/alpine bearberry (O12) is an accessory v.t. that occurs on avalanche path margins. Minor amounts of the Engelmann spruce-subalpine fir/willow/hairy wild rye (O18) and Engelmann spruce-subalpine fir/mountain avens (O19) v.t.s occupy similar physiographic positions. Small amounts of the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. occur on WF3 tracts in southern Banff. A variety of v.t.s associated with avalanched portions (WF3A) occur. Unvegetated portions, associated with rubbly colluvium and Regosolic soils occur on intensely active sites. A plot representing the Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) v.t. of the WF3 Ecosite is described in Table 380 and shown in Plate 38. It represents vegetation at the pedon sample site described in Table 379.

Discussion

In terms of landform surface expression, physiographic position and vegetation cover, WF3 resembles the Whitehorn 5 (WH5) and Endless Chain 3 (EN3) Ecosites. However, in constrast to the Colluvium C of WF3, WH5 occurs on colluvial landforms consisting of noncalcareous, medium textured colluvium (Colluvium B) and EN3 occurs on noncalcareous, coarse textured colluvium (Colluvium A). Also, both WH5 and EN3 have Dystric, instead of Eutric, Brunisols. The other WF Ecosites are differentiated from WF3 primarily by vegetation differences as outlined in Table 374. The Sawback 4 (SB4) Ecosite is the Lower Subalpine counterpart to WF3.

Table 380 Stand (LC9181) illustrating the Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (04) v.t. of the WF3 Ecosite.

TREE LAYER	
Abies lasiocarpa	02
Picea engelmannii	08
Pinus albicaulis	04
Pinus contorta	01
TALL SHRUB LAYER	
Abies lasiocarpa	05
Pinus albicaulis	05
SHRUB LAYER	
Abies lasiocarpa	04
Juniperus communis	10
Pinus albicaulis	04
Salix glauca	01
Salix vestita	01
HERB-DWARF SHRUB LAYER	
Arctostaphylos uva-ursi	12
Aster spp.	01
Calamagrostis montanensis	01
Carex spp.	02
Dryas octopetala	.5
Elymus innovatus	03
Juniperus communis	05
Linnaea borealis	03
Pinus contorta	.5
Zygadenus elegans	03
BRYOID LAYER	
Cetraria nivalis	.5
Cladonia pyxidata	01
Peltigera rufescens	01
Xanthoria elegans	.5
EPIPHYTES	
Bryoria fuscescens	.5
Hypogymnia austerodes	.5
Letharia vulpina	.5
Parmeliopsis ambigua	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

WF4 - WILDFLOWER 4 ECOSITE

Ecosite Concept

The Upper Subalpine WF4 Ecosite encompasses blankets and veneers comprised of calcareous, medium textured colluvium (Colluvium C) that mantle underlying inclined bedrock on steep valley walls. The WF4 Ecosite is dominated by rapidly to well drained Orthic Eutric Brunisols and Orthic Regosols. Vegetation is dominated by the Engelmann spruce/hairy wild rye (C33) v.t. The WF4 Ecosite predominantly occurs on southerly aspects in the Front Ranges subprovince in both Banff and Jasper. Tracts of WF4 are most abundant in eastern Banff.

Geomorphology

The WF4 Ecosite encompasses blankets and veneers comprised of calcareous, medium tex-

Table 381 Pedon (Alberta 1979 No. 93) description of an Orthic Eutric Brunisol of the WF4 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: WF4.

LOCATION: MILITARY GRID REF. 11 UNN 8310 970; NTS MAP AREA 82O 12H.

CLIMATE: 2180 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 5 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JD9084*VTN=C33*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), COLLUVIAL; LANDFORM CLASSIFICATION: ACTIVE COLLUVIAL, BLANKET; SLOPE: 70% SLOPE OF CLASS 8 (46-70%), FACING SOUTHEAST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,300 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPIDLY PERVIOUS, VERY RAPID SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; SLIGHTLY ROCKY.

SPECIAL NOTES: SSN=WT9152*APN=010-164*RLU=15*PCF=4AG,3AC(3-5)3AG,2GR,3AC,2CB(6)*LFH=CB/R1*CK2 WEAKLY CEMENTED*MAY PERHAPS BE CLASSIFIED MORE APPROPRIATELY AS AN ORTHIC REGOSOL*DATE=SEPT.6,1979*

L: 10 TO 6 CM, RANGE 2 TO 8 CM; MATRIX MOIST 10YR 5/3; WAVY, ABRUPT HORIZON BOUNDARY.

F: 6 TO 0 CM, RANGE 5 TO 7 CM; MATRIX MOIST 10YR 2/2; PLENTIFUL, COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BMK1: 0 TO 13 CM, RANGE 10 TO 14 CM; MATRIX MOIST 7.5YR 3/2; LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT CONSISTENCE; ABUNDANT, MEDIUM AND COARSE ROOTS; MODERATE EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

BMK2: 13 TO 30 CM, RANGE 15 TO 20 CM; MATRIX MOIST 7.5YR 4/4; SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT CONSISTENCE; PLENTIFUL, MEDIUM AND COARSE ROOTS; MODERATE EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CK1: 30 TO 90 CM, RANGE 55 TO 65 CM; MATRIX MOIST 10YR 5/3; SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT CONSISTENCE; PLENTIFUL, FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; WAVY, CLEAR HORIZON BOUNDARY.

CK2: 90 TO 105 CM; MATRIX MOIST 10YR 5/2; SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SLIGHTLY HARD CONSISTENCE; FEW, FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
L	6.3	57.10	
F	6.1	36.20	
BMK1	7.5		51.1
BMK2	7.5		74.5
CK1	7.6		88.7
CK2	7.7		74.0

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
L				
F				
BMK1	0.1		-.1	
BMK2	0.1		-.1	
CK1				
CK2				

PHYSICAL DATA (SURVEY)

	% PASSING				PARTICLE SIZE ANALYSIS						% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	78-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
L														
F														
BMK1					7	11	8	8	12	46		44	10	
BMK2					11	12	7	7	13	50		45	5	
CK1					4	8	9	11	21	51		43	6	
CK2		99	89	60	9	11	11	14	16	61		35	4	
		99	78	56	50									

PHYSICAL DATA

	ENGINEERING							
HORIZON	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
L								
F								
BMK1								
BMK2							24	07
CK1							12	07
CK2								

tured colluvium (Colluvium C) that mantle inclined bedrock on steep valley walls. Underlying bedrock strata are predominantly calcareous. Geomorphic activity primarily consists of surface modification by sheet erosion and colluviation. Avalanching and related processes also occur occasionally. These tracts are mapped as WF4A when 20 to 50% of the landscape is affected. Veneers of altered, medium textured eolian material (Eolian material B) may occur sporadically and are associated with stabilized, non-eroding sites.

Topographically, WF4 displays linear, inclined slopes commonly ranging from 45 to 90%. Surface form is controlled by deposition and underlying bedrock.

Soils

Soil distribution and development on the WF4 Ecosite reflect varying degrees of surface modification. Orthic Eutric Brunisols and Orthic Regosols are the dominant soils. Orthic Eutric Brunisols occupy portions of the landscape where surface modification is weak but sufficient to retard or destroy eluvial (Ae) horizon development. Orthic Regosols occur on portions of tracts that are more severely modified by erosional and colluvial processes. Orthic Melanic Brunisols occur as accessory soils.

Soils of WF4 are rapidly to well drained and reflect, in their development, the calcareous, medium textured parent material. Orthic Eutric Brunisols have thin sola and weakly developed Bm or Bmk horizons. Orthic Regosols and accessory Orthic Melanic Brunisols have various thicknesses of Ah horizons. These have built up by a combination of organic matter incorporation into the surface and physical accretion of organic rich material from upslope. A pedon illustrating Orthic Eutric Brunisols of the WF4 Ecosite is described in Table 381 and shown in Color Plate 85. This pedon was sampled in the Panther River valley in Banff.

Vegetation

Mature vegetation cover of the WF4 Ecosite indicates low intensity geomorphic activity and relatively dry moisture status. The Engelmann spruce/hairy wild rye (C33) v.t. is dominant. The Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) is an accessory v.t. commonly found at lower elevations than C33. Other accessory v.t.s found on tracts of WF4 include Engelmann spruce-subalpine fir/willow/hairy wild rye (O18) and hairy wild rye-junegrass-bearberry (H14). A stand illustrating the Engelmann spruce/hairy wild rye (C33) v.t. is described in Table 382 and shown in Plate 180. It represents vegetation at the pedon sample site described above in Table 381.

Discussion

The WF4 Ecosite is separated from the other WF Ecosites primarily on vegetational differences as outlined in Table 374.

Table 382 Stand (JD9084) illustrating the Engelmann spruce/hairy wild rye (C33) v.t. of the WF4 Ecosite.

TREE LAYER	
Picea engelmannii	35
TALL SHRUB LAYER	
Picea engelmannii	.5
SHRUB LAYER	
Abies lasiocarpa	.5
Juniperus communis	.5
Picea engelmannii	.5
Shepherdia canadensis	.5
HERB-DWARF SHRUB LAYER	
Achillea millefolium	01
Agoseris glauca	.5
Androsace chamaejasme	.5
Arctostaphylos uva-ursi	02
Carex concinna	.5
Cirsium hookerianum	.5
Elymus innovatus	40
Hedysarum sulphurescens	05
Linnaea borealis	01
Potentilla fruticosa	.5
Solidago multiradiata	03
Zygadenus elegans	02
BRYOID LAYER	
Brachythecium spp.	01
Ceratodon purpureus	.5
Cladonia pyxidata	01
Distichium capillaceum	01
Drepanocladus uncinatus	.5
Hypnum revolutum	01
Lecidea berenberiana	.5
Peltigera canina	.5
Tetraplodon mnioides	.5
Tortula norvegica	.5
EPIPHYTES	
Alectoria spp.	.5
Hypogymnia austerodes	.5
Letharia vulpina	.5
Parmelia elegantula	.5
Usnea spp.	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

WF7 - WILDFLOWER 7 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, WF7, encompasses colluvial blankets and veneers comprised predominantly of calcareous, medium textured colluvium (Colluvium C) overlying inclined bedrock on steep valley walls. Occasionally, it also includes noncalcareous, medium textured colluvium (Colluvium B). Soils of the WF7 Ecosite reflect varying amounts of humus accumulation and degrees of surface modification by soil creep. Orthic Eutric Brunisols, Orthic Melanic Brunisols, and Orthic and Cumulic Humic Regosols typify the soils. A vegetation pattern in which the hairy wild rye-junegrass-bearberry

(H14) is dominant and the willow-dwarf birch-shrubby cinquefoil (S10) and mountain avens-kobresia-bearberry (H4) v.t.s are subdominant, is characteristic. Distribution of these v.t.s reflects exposure and elevation differences. Tracts mapped as WF7 primarily occur in the Front Ranges in both Banff and Jasper.

Geomorphology

The WF7 Ecosite encompasses colluvial blankets and veneers comprised predominantly of calcareous, medium textured colluvium (Colluvium C) overlying inclined bedrock on steep valley walls. Occasionally, it also includes noncalcareous, medium textured colluvium (Colluvium B). The colluvial material is derived nearly exclusively from Mesozoic strata. Geomorphic activity on WF7 primarily consists of soil creep. Till occasionally underlies colluvial material along lower slopes.

Topographically, WF7 displays linear, inclined slopes commonly ranging from 45 to 90%. Surface form is controlled by deposition and underlying bedrock. Thin colluvial veneers dominate tracts mapped as WF7X. Tracts with failed slopes (WF7F), including failure of unconsolidated material and partial failure of underlying bedrock, occur occasionally.

Table 383 Pedon (Alberta 1979 No. 97) description of an Orthic Melanic Brunisol of the WF7 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC MELANIC BRUNISOL. SOIL MAP UNIT: NOTATION: WF7.

LOCATION: MILITARY GRID REF. 11 UNH 5545 1635; NTS MAP AREA 82O 12H.

CLIMATE: 1980 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 3 DEG(C) AT 50 CM IN OCTOBER, NO. 2 WAS 3 DEG(C) AT 25 CM IN OCTOBER, NO. 3 WAS 2 DEG(C) AT 5 CM IN OCTOBER.

VEGETATION: VPN=PA9139*VTN=H14.

SOIL SITE: PARENT MATERIAL 1: SHATTERED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), COLLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: COLLUVIAL, COBBLY, INCLINED; SLOPE: 55% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING SOUTHWEST, SITE AT LOWER SLOPE POSITION, SLIGHTLY ROUNDED MICROTOPOGRAPHY,1000 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY.

SPECIAL NOTES: SSH=SC9081*APH=015-180*PCF=2AGR(1)3AGR.2ACB(2-3)3AGR.3ACB.2ST(4)*DATE=OCT.17,1979*

AH: 0 TO 14 CM, RANGE 12 TO 16 CM; MATRIX MOIST 10YR 2/2, CRUSHED DRY 10YR 2/2; SILT LOAM; WEAK, COARSE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE ROOTS; HIGHLY POROUS, COMMON, VERY FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

BM: 14 TO 38 CM, RANGE 15 TO 25 CM; MATRIX MOIST 7.5YR 3.5/4, CRUSHED DRY ; SILT LOAM; WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE ROOTS; HIGHLY POROUS, FEW, VERY FINE PORES; WAVY, CLEAR HORIZON BOUNDARY.

BC: 38 TO 50 CM, RANGE 8 TO 18 CM; MATRIX MOIST 10YR 3/2, CRUSHED DRY 10YR 3/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; WEAK, FINE, SUBANGULAR BLOCKY SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MICRO ROOTS; HIGHLY POROUS, FEW, VERY FINE PORES; WAVY, GRADUAL HORIZON BOUNDARY.

CK: 50 TO 110 CM; 10YR 2.5/2, CRUSHED DRY 10YR 3/3; SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MICRO ROOTS; HIGHLY POROUS, FEW, VERY FINE PORES; VERY STRONGLY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	TOTAL N (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
AH	6.4	15.60	1.00		40.1		33.8	8.4	0.2	0.5
BM	6.6	3.00		0.7	16.0		16.1	4.3	0.0	0.1
BC	7.1			14.0						
CK	7.4			33.5						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
AH				
BM	0.1		-.1	
BC				
CK				

PHYSICAL DATA (SURVEY)

HORIZON	PARTICLE SIZE ANALYSIS % PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
AH										35		52	13	
BM										35		53	12	
BC										41		52	7	
CK	99	67	40	29						48		47	5	

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AH								
BM								
BC								
CK	25.0	31.0					12	03

Soils

Soil distribution and development on the WF7 Ecosite reflect varying amounts of humus accumulation and degrees of surface modification by soil creep. The rapidly to well drained soils of WF7 primarily occur on southerly aspects and are dominated by Orthic Eutric Brunisols, Orthic Melanic Brunisols, Orthic Humic Regosols, and Cumulic Humic Regosols. Orthic Eutric Brunisols are associated with moderately eroded localities where removal is or has been more important than accretion. These soils generally have weakly developed Bm or Bmk horizons. Eluvial (Ae) horizons are absent but thin Ah or Ahk horizons are common. Orthic Melanic Brunisols and Orthic and Cumulic Humic Regosols occur where accretion is important. They have thick Ah or Ahk horizons physically built up by the accumulation of organo-mineral erosional products. Orthic Regosols and Orthic Sombric Brunisols occur as accessory soils. Orthic Regosols may have thin Ah or Ahk horizons and are generally associated with sites where removal is more important than accretion. Cumulic Regosols occur in minor amounts. A pedon illustrating Orthic Melanic Brunisols of WF7 is described in Table 383 and shown in Color Plate 86. This pedon was sampled on the southwest facing slope of Mount White in Banff. Soil and air temperatures at this site have been monitored since October, 1979. The data indicate that this profile can also be classified as an Orthic Dark Brown in the Chernozemic Order. The C.S.S.C. (1978b) recognizes the ambiguity that exists for separating some Melanic Brunisols from Chernozemic soils, especially in Subalpine and Alpine areas.

Vegetation

Vegetation of the WF7 Ecosite is distributed in a pattern governed by aspect, exposure and elevation. The hairy wild rye-junegrass-bearberry (H14) v.t. is dominant and the willow-dwarf birch-shrubby cinquefoil (S10) and mountain avens-kobresia-bearberry (H4) v.t.s are subdominant. The H4 v.t. occurs at higher elevations than H14 but intergrades occur. The Engelmann spruce-subalpine fir/willow/hairy wild rye (O18), willow/cinquefoil (S8), and willow/hairy wild rye (S12) v.t.s occur sporadically as accessory v.t.s. The mountain avens-snow willow-moss campion (H1) v.t. occurs in minor amounts at higher elevations near the Alpine boundary. The thick root mats of grassland v.t.s aid in stabilizing the steep slopes on WF7. Unvegetated portions, associated with rubbly colluvium and Regosolic soils occur on intensely active sites. A plot illustrating the hairy wild rye-junegrass-bearberry (H14) v.t. is described in Table 384 and shown in Plate 181. It represents vegetation at the pedon sample site described above in Table 383.

Table 384 Stand (PA9139) illustrating the hairy wild rye-junegrass-bearberry (H14) v.t. of the WF7 Ecosite.

	HERB-DWARF SHRUB LAYER
Achillea millefolium	01
Agrostis variabilis	.5
Androsace septentrionalis	.5
Anemone multifida	10
Anemone patens	03
Antennaria nitida	.5
Artemisia frigida	.5
Cerastium arvense	.5
Delphinium glaucum	02
Elymus innovatus	60
Fragaria virginiana	05
Gaillardia aristata	02
Geum triflorum	.5
Hedysarum sulphurescens	15
Myosotis alpestris	.5
Oxytropis splendens	.5
Potentilla nivea	.5
Potentilla pensylvanica	.5
Zygadenus elegans	.5
	BRYOID LAYER
Drepanocladus uncinatus	.5
Tortula ruralis	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT.

Discussion

In terms of vegetation cover, the WF7 Ecosite resembles the Tyrrell 2 (TR2) and Cyclone 1 (CN1) Ecosites. However, rather than the colluvial landforms of WF7, TR2 occurs on morainal landforms, CN1 on fluvial landforms. The WF7 Ecosite is separated from the other WF Ecosites primarily on vegetational differences as outlined in Table 374. The Sawback 5 (SB5) Ecosite is the Lower Subalpine counterpart to WF7.

WH - WHITEHORN ECOSECTION

The Whitehorn (WH) Ecosection encompasses steep, linear landforms comprised of noncalcareous, medium textured colluvium (Colluvium B) in the Upper Subalpine portion of the Subalpine Ecoregion. It occurs on or below steep valley walls and is associated with Miette Group or noncalcareous Mesozoic strata. Varying type and degree of colluvial activity, aspect, exposure, and lithology govern soil and vegetation development and distribu-

tion. The WH Ecosection is characterized by Dystric Brunisols associated with heterogeneous avalanche complex vegetation, subalpine larch-subalpine fir forest, Engelmann spruce-subalpine fir open and closed forest, and mixed open coniferous forest.

Four Ecosites (WH1, WH2, WH3, WH5) are recognized within the WH Ecosection and are separated primarily on vegetation differences. Table 385 outlines the features of the WH Ecosites and Fig. 54 shows their relationship on the landscape and to other Ecosites.

WH1 - WHITEHORN 1 ECOSITE

Ecosite Concept

The Upper Subalpine WH1 Ecosite encompasses blankets and veneers comprised of noncalcareous, medium textured colluvium (Colluvium B) overlying inclined bedrock on steep valley walls. The soils of WH1, Orthic and Eluviated Dystric Brunisols and Orthic Sombric Brunisols, suggest by their development that colluviation is essentially inactive. Likewise, vegetation is mature and is dominated by the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. Tracts of WH1 only occur in southern Banff south of Hector Lake and Pipestone Pass.

Geomorphology

The WH1 Ecosite occurs on colluvial blankets and veneers consisting of noncalcareous, medium textured colluvium (Colluvium B) overlying inclined bedrock on steep valley walls. Source bedrock is predominantly Miette Group and noncalcareous Mesozoic strata. Surface veneers of altered, medium textured eolian material (Eolian material B) occur. On portions of some tracts the veneer has been removed or incorporated by erosional and colluvial processes. Till occasionally underlies colluvial material along lower, more gentle slopes of WH1 tracts.

Topographically, WH1 displays long, linear slopes commonly ranging from 45 to 70%. Surface form is controlled by deposition and underlying bedrock. The colluvial material is generally shallowest (veneers) at the tops of slopes and deepens downslope.

Soils

The well drained soils of the WH1 Ecosite reflect in their development the acidic, medium textured parent material and relatively stable geomorphic conditions. Orthic and Eluviated Dystric Brunisols and Orthic Sombric Brunisols are dominant. In the near Alpine environment with larch forest vegetation, organic matter accumulation in upper sola of these soils is evident, often masking the effects of eluviation. Locally, colluviation has physically thickened surface organo-mineral horizons (Orthic Sombric Brunisols). Orthic Dystric Brunisols also occur on localities where eluvial (Ae) horizon development is inhibited or destroyed by surface disturbances. These Brunisolic soils have moderately to strongly developed B horizons. Strongly developed Bm and Bf horizons occur where Eolian material B veneers are present. Accessory Orthic Humo-Ferric Podzols are associated with these veneers and have podzolic Bf horizons above the parent material disconformity. A pedon illustrating Orthic Sombric Brunisols of the WH1 Ecosite is described in Table 386 and shown in Color Plate 87. This pedon was sampled on the west slope of Lipalian Mountain in Banff.

Vegetation

Vegetation cover on the WH1 Ecosite reflects relatively stable geomorphic conditions. The subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. is dominant. This v.t. only occurs in southern Banff south of Hector Lake and Pipestone Pass. Open variants of C23 occur on exposed sites and along the upper elevational boundaries of WH1 tracts. Stunted variants or other avalanche v.t.s such

Table 385 General features of the Whitehorn (WH) Ecosites.

Ecosite	Landform	Soils	Vegetation
WH1	Colluvium B; blanket, veneer	Dystric Brunisol, Sombric Brunisol	subalpine larch-subalpine fir forest
WH2	Colluvium B; blanket, veneer	Dystric Brunisol	Engelmann spruce-subalpine fir open and closed forests
WH3	Colluvium B; blanket, veneer, apron	Dystric Brunisol, Sombric Brunisol, Humic Regosol	Avalanche Complex 2 > Engelmann spruce-subalpine fir open and closed forests
WH5	Colluvium B; blanket, veneer > bedrock; inclined	Dystric Brunisol > Regosol	mixed coniferous open forest > Engelmann spruce-subalpine fir open forest

Figure 54 Landscape schematic showing the relationship of the Whitehorn (WH) Ecosites to other Ecosites.

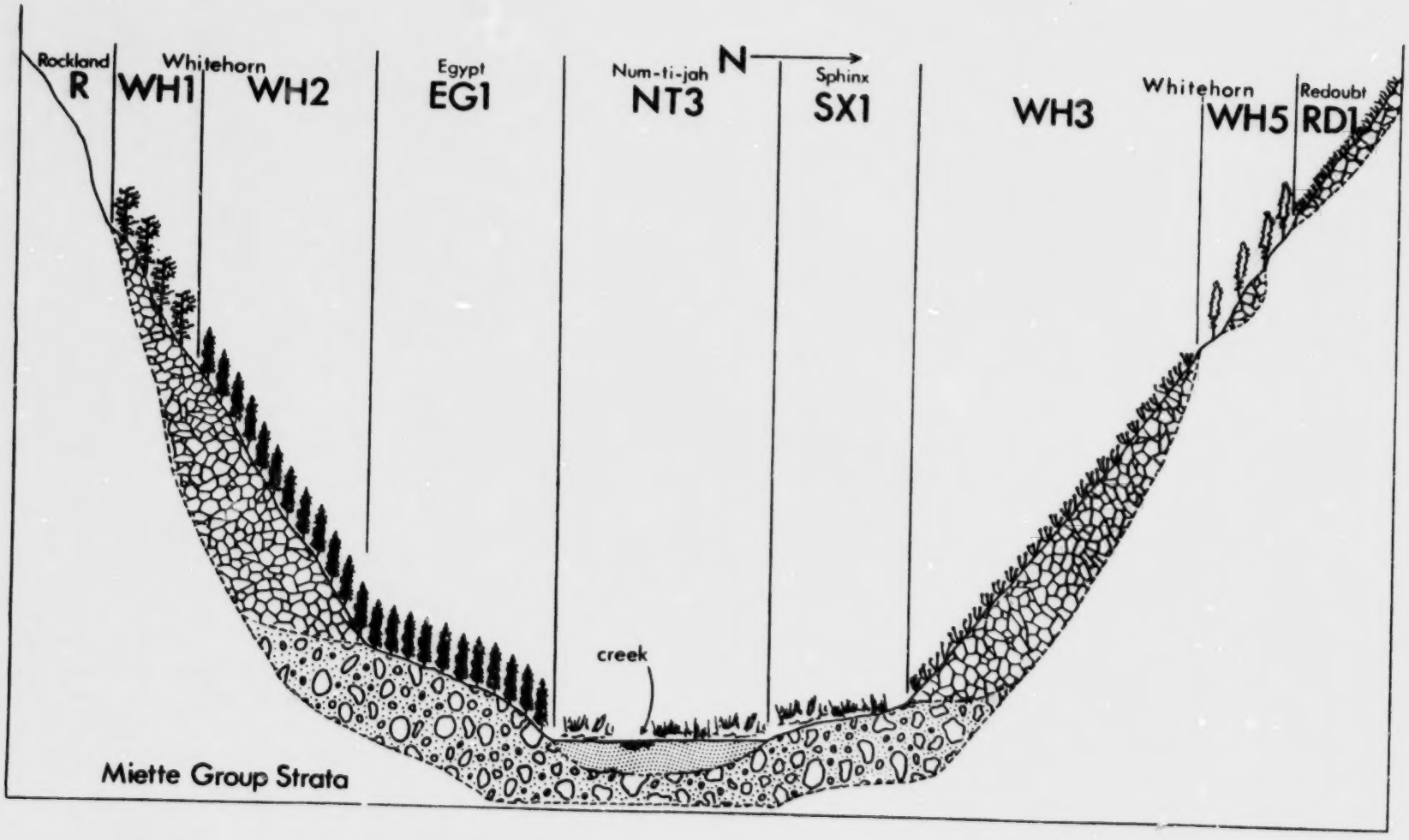


Table 386 Pedon (Alberta 1978 No. 82) description of an Orthic Sombric Brunisol of the WH1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC SOMBRIC BRUNISOL. SOIL MAP UNIT: NOTATION: WH1.

LOCATION: MILITARY GRID REF. 11 UNG 6210 9830; NTS MAP AREA 82N 8E.

CLIMATE: 2300 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 3 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VPN=JC8897=VTN=CE3=.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), COLLUVIAL, SLATE; DEPTH TO BEDROCK IS 2 M; LANDFORM CLASSIFICATION: COLLUVIAL, VENEER; SLOPE: 57% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING WEST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,150 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; SLIGHTLY STONY; SLIGHTLY ROCKY.

SPECIAL NOTES: SSN=WT8161=APN=783-102=RLU=12=PCF-2AGR,2CH(2-3)1AGR,1CB(4)1AGR,3CN(5)4AGR,4CN,2ACB(6-7)=LFM=CV/RI=

LF: 4 TO 0 CM, RANGE 2 TO 5 CM; MATRIX MOIST 10YR 2/1; PLENTIFUL, VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AH: 0 TO 13 CM, RANGE 11 TO 15 CM; MATRIX MOIST 7.5YR 3/2; COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE AND MEDIUM AND COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BF: 13 TO 18 CM, RANGE 4 TO 7 CM; MATRIX MOIST 7.5YR 4/4; COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, MICRO AND VERY FINE AND FINE AND MEDIUM AND COARSE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BM1: 18 TO 21 CM, RANGE 2 TO 4 CM; MATRIX MOIST 7.5YR 5/7; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; VERY FEW, MICRO AND VERY FINE AND FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

BM2: 21 TO 36 CM, RANGE 13 TO 16 CM; MATRIX MOIST 2.5Y 6/3; COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; FRIABLE CONSISTENCE; FEW, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY; EXTREMELY ACID <4.5 FIELD PH.

BC: 36 TO 90 CM, RANGE 44 TO 64 CM; MATRIX MOIST 10YR 6/4; GRAVELLY COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; VERY FEW, MICRO AND VERY FINE AND FINE AND MEDIUM AND COARSE ROOTS; WAVY, DIFFUSE HORIZON BOUNDARY.

C: 90 TO 123 CM; MATRIX MOIST 5Y 6/2; GRAVELLY SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; VERY FEW, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.8	39.40						
AH	4.6	4.40	14.9		2.2	1.0	-.1	0.2
BF	4.8	2.90	11.9		1.1	0.4	-.1	0.1
BM1	5.1	4.00	14.1		1.4	0.7	1.1	0.1
BM2	4.9	0.50	7.2		1.6	0.7	0.1	0.1
BC	4.8		6.2		2.0	0.8	-.1	0.1
C	6.5		6.3		2.5	1.5	0.1	0.1

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AH				
BF	0.3		0.4	
BM1	0.2		-.1	
BM2	0.1		-.1	
BC				
C				

PHYSICAL DATA (SURVEY)

HORIZON	X PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	X OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF												36	4	
AH					18	15	10	10	7	60		40	5	
BF					18	16	8	8	5	55		46	5	
BM1					5	6	4	4	10	29		66	5	
BM2					16	15	8	8	7	54		44	2	
BC					26	19	10	7	4	66		29	5	
C	99	70	33	20	11	13	7	5	4	40		50	10	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AH		15.3	6.2										
BF													
BM1													
BM2													
BC													
C		13.9	5.4			17.0	21.0		13.0	1.8		11	17

as subalpine fir-willow (S2) occur on avalanche paths. Because of areas too small to map at 1:50,000, WH1 tracts have minor amounts of the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21), Engelmann spruce-subalpine fir/heather/feathermoss (C34) or Engelmann spruce-subalpine fir/heather (O10) v.t.s along lower elevational boundaries and the Engelmann spruce-subalpine fir/mountain avens (O19) v.t. and patches of the heather-everlasting (L5) v.t. along upper boundaries. A stand illustrating the subalpine larch-subalpine fir/grouseberry-everlasting v.t. of the WH1 Ecosite is described in Table 387 and shown in Plate 182 and represents vegetation at the pedon sampling site described above (Table 386).

Table 387 Stand (JC8097) illustrating the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. of the WH1 Ecosite.

TREE LAYER	
Abies lasiocarpa	03
Larix lyallii	15
Picea engelmannii	07
TALL SHRUB LAYER	
Abies lasiocarpa	01
Larix lyallii	01
Picea engelmannii	.5
SHRUB LAYER	
Abies lasiocarpa	02
Larix lyallii	01
HERB-DWARF SHRUB LAYER	
Antennaria lanata	01
Arnica latifolia	.5
Castilleja occidentalis	.5
Erigeron peregrinus	.5
Festuca saximontana	.5
Juniperus communis	02
Luzula wahlenbergii	.5
Poa spp.	01
Potentilla diversifolia	.5
Saxifraga bronchialis	.5
Sibbaldia procumbens	.5
Trisetum spicatum	.5
Vaccinium scoparium	38
BRYOID LAYER	
Brachythecium spp.	03
Cetraria islandica	.5
Cladonia ecmocyna	02
Peltigera aphthosa	01
Peltigera rufescens	.5
Polytrichum juniperinum	.5
Polytrichum piliferum	05
Tortula spp.	05
Barbilophozia lycopodioides	02
EPIPHYTES	
Letharia vulpina	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Discussion

WH1 is the least extensive of the Whitehorn Ecosites. Its distribution is governed by the narrow elevational (2200-2400 m) and geographic range of the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. on Colluvium B. Occasionally the C23 v.t. occurs on the other colluvial genetic material units (Colluviums A and C) resulting in landscape that resembles WH1. C23 also occurs on morainal landforms in the Upper Subalpine. WH1 is separated from the other WH Ecosites primarily by vegetational differences (Table 385).

WH2 - WHITEHORN 2 ECOSITE

Ecosite Concept

The Upper Subalpine WH2 Ecosite encompasses blankets and veneers comprised of noncalcareous, medium textured colluvium (Colluvium B) overlying inclined bedrock on steep valley walls. The soils are dominated by Orthic and Eluviated Dystric Brunisols. Vegetation is dominated by the Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/heather (O10) and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s Of these, C15 and O10 are the most abundant.

Geomorphology

The WH2 Ecosite occurs on colluvial blankets and veneers consisting of noncalcareous, medium textured colluvium (Colluvium B) overlying inclined bedrock on steep valley walls. Underlying bedrock is predominantly Miette Group or noncalcareous Mesozoic strata. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically and are most abundant on WH2 tracts of western Banff and southwestern Jasper. Erosional and colluvial processes have removed or incorporated most evidence of the wind blown accumulation. Till occasionally underlies colluvial material along lower, more gentle slopes of WH2 tracts. Thin fluvial deposits, generally a weakly sorted variant of noncalcareous, coarse, stratified fluvial material (Fluvial material A), occasionally are interbedded with colluvium on avalanched portions of WH2A tracts.

Topographically, WH2 displays long, linear slopes commonly ranging from 45 to 70%, occasionally to 90%. Surface form is controlled be deposition and underlying bedrock. The colluvial material is generally shallowest (veneers) at the tops of slopes and deepens downslope. Minor amounts of colluvial aprons occur along slope bases at abrupt topographic changes.

Soils

The well to moderately well drained soils of the WH2 Ecosite reflect in their development acidic, medium textured parent material and relatively stable geomorphic conditions. Orthic and Eluviated Dystric Brunisols are dominant. These Brunisols have moderately to strongly developed B horizons. Orthic Dystric Brunisols occupy localities where surface disturbances are sufficient to inhibit or destroy Ae horizon development. Sites that have been stable for sufficient time have Eluviated Dystric Brunisols. Orthic Humo-Ferric Podzols are accessory soils and are associated with Eolian material B veneers. Orthic Regosols are accessory soils that occur on rubbly and actively colluviating sites. Minor amounts of Orthic and Eluviated Eutric Brunisols occur, in areas too small to delineate, on weakly calcareous Mesozoic strata in the Bosche Range in Jasper. The soils of the WH1 Ecosite are similar to those of WH2 except that Ah horizons in the latter are thinner or absent. Soils of WH2 are also similar to soils on stable portions of WH3 and WH5.

Vegetation

Vegetation cover of the WH2 Ecosite reflects relatively stable geomorphic conditions. The Engelmann spruce-subalpine fir/grouseberry (C15), Engelmann spruce-subalpine fir/heather (O10), and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s are dominant. Of these, C15 and O10 are most abundant, however, a few tracts of WH2 are dominated by C21. The C21 v.t. replaces C15 throughout northern Jasper (north of the range of *Vaccinium scoparium*) and on some tracts near the Continental Divide. On a slope, O10 generally occurs above C15 and C21. Many tracts have up to 50% of their area avalanched. Areas 20 to 50% avalanched are mapped as WH2A and have avalanche v.t.s such as fleabane-valerian (H16). A stand representing the Engelmann spruce-subalpine fir/heather (O10) v.t. of the WH2 Ecosite is described in Table 388.

Table 388 Stand (LC9017) illustrating the Engelmann spruce-subalpine fir/heather(O10)v.t. of the WH2 Ecosite.

TREE LAYER	
Abies lasiocarpa	08
Picea engelmannii	12
TALL SHRUB LAYER	
Picea engelmannii	05
SHRUB LAYER	
Abies lasiocarpa	05
Picea engelmannii	05
Pinus contorta	.5
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	15
Arctostaphylos uva-ursi	03
Artemisia norvegica	05
Cassiope tetragona	15
Danthonia intermedia	.5
Dryas octopetala	15
Festuca spp.	02
Juniperus communis	.5
Phyllodoce spp.	15
Pyrola secunda	.5
Salix arctica	03
Saxifraga tricuspidata	.5
Vaccinium vitis-idaea	.5
Equisetum scirpoides	05
BRYOID LAYER	
Brachythecium spp.	.5
Cetraria nivalis	02
Cladonia pyxidata	01
Cladonia verticillata	01
Dicranum scoparium	.5
Drepanocladus uncinatus	.5
Hylocomium splendens	10
Nephroma expallidum	01
Peltigera aphthosa	10
Pleurozium schreberi	.5
Polytrichum juniperinum	.5
Tortula norvegica	10
Tortula ruralis	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 05 INDICATES THE SPECIES WAS PRESENT

Discussion

In terms of landform surface expression, physiographic position and vegetation cover, WH2 resembles the Wildflower 1 (WF1) and Endless Chain (EN1) Ecosites. However, rather than the Colluvium B of WH2, WF1 occurs on landforms consisting of calcareous, medium textured colluvium (Colluvium C) and EN1 occurs on noncalcareous, coarse textured colluvium (Colluvium A). Also, WF1 has neutral to alkaline Eutric rather than Dystric Brunisols and a significant amount of Regosolic soils. The soils of EN1, like WH2, are characterized by Dystric Brunisols but have thicker sola and better developed eluvial (Ae) horizons. The other WH Ecosites are separated from WH2 primarily by vegetation differences (Table 385) that reflect varying type and degree of colluvial activity. The Fairview 2 (FV2) Ecosite, occurring on landforms of noncalcareous, medium textured colluvium (Colluvium B), is the Lower Subalpine counterpart to WH2.

WH3 - WHITEHORN 3 ECOSITE

Ecosite Concept

The Upper Subalpine WH3 Ecosite encompasses avalanched colluvial landforms comprised of noncalcareous, medium textured colluvium (Colluvium B). These exist as blankets and veneers overlying inclined bedrock on steep valley walls and as aprons along slope bases at major slope breaks. Snow avalanching is characteristic and governs the distribution of vegetation and, to a lesser extent, soils. A soil pattern, in which Orthic Dystric Brunisols and Orthic Sombric Brunisols are dominant and Orthic Humic REgosols and Cumulic Humic Regosols are subdominant, typifies the soil component of WH3. Avalanching on WH3 is most common on coalescing unconfined tracks and thus avalanched segments are dominant. They are characterized by a heterogeneous complex of v.t.s that include subalpine fir-willow (S2), willow-dwarf birch-shrubby cinquefoil (S10), juniper-willow (L2), hairy wild rye-wild strawberry-fireweed (H5), fleabane-valerian (H16) plus intergrades, collectively called Avalanche Complex 2. Forested strips and patches between avalanche tracks and fringing runout zones are subdominant and best represented by the Engelmann spruce-subalpine fir/grouseberry (C15) and Engelmann spruce-subalpine fir/heather (O10) v.t.s.

Geomorphology

The WH3 Ecosite occurs on blankets, veneers and aprons comprised of noncalcareous, medium textured colluvium (Colluvium B). Underlying bedrock is predominantly Miette Group or noncalcareous Mesozoic strata. More than 50% of WH3 is modified by snow avalanching. Avalanching of such areal extent usually occurs with coalescing unconfined avalanche paths (Plate 183) or as runout zones below the length of a cliff. Gully-like channeled avalanche tracks are common as well. Perla and Martinelli (1975) discuss the terminology of snow avalanching.

Genetic material stability within WH3 tracts is greatest on portions unaffected by avalanching, but the unconfined tracks are almost as stable. Together these components make up the majority of the area of WH3 tracts. Instability is of two kinds. Erosion of unconsolidated material occurs, though infrequently, on steep avalanche starting zones and walls of channelled tracks. It is usually evidenced by sparsely vegetated patches. Deposition is a more common process and frequently includes material derived from bedrock exposures high on or above the WH3 tract. Material carried by avalanching is distributed downslope to gentler runout zones. Colluvial material is modified by intermittent streams below couloirs and on avanlanche runout zones. Fluvial deposits, occurring as thin veneers and as layers interbedded with colluvium, are most abundant below channeled tracks and couloirs. This fluvial material is a weakly sorted variant of noncalcareous, coarse, stratified fluvial material (Fluvial material A) and, like the colluvium, is medium textured with a high content of angular coarse fragments. Surface veneers of altered, medium textured eolian material (Eolian material B) occur sporadically on the subdominant unavalanched segments of the landscape. Rubble lacking fine earth material for soil development is common on some WH3 tracts, particularly those occurring as aprons below steep rock walls where cliff forming Gog Group quartzite overlies Miette Group strata.

Topographically, WH3 dislays long, linear, inclined slopes commonly ranging from 45 to 90%. Slopes <45% occur on avalanche runout zones on gentler lower slopes and toes of colluvial aprons. Surface form is controlled by deposition and underlying bedrock. The colluvial material is generally shallowest (veneers) at the tops of slopes and deepens downslope to form aprons along slope bases at abrupt changes in slope. Colluvial aprons also occur below rock walls. Fans constructed by intermittent streams are often associated with minor gullying upslope on avalanche tracks.

Soils

Soil distribution and development on the WH3 Ecosite is related to genetic material stability as influenced by avalanching and supplementary processes. A soil pattern, in which Orthic Dystric Brunisols and Orthic Sombric Brunisols are dominant and Orthic Humic Regosols and Cumulic Humic Regosols are subdominant, characterizes WH3. Humus accumulation in upper sola of these soils is evident, often masking the effects of eluviation. Locally, colluvial accretion has physically thickened surface organo-mineral horizons (Orthic Sombric Brunisols, Orthic Humic Regosols, Cumulic Humic Regosols). Orthic Dystric Brunisols occur on localities where eluvial (Ae) horizon development is masked by humus incorporation or inhibited or destroyed by surface disturbances. Accessory Orthic Regosols and minor amounts of Cumulic Regosols occupy localities where erosion or deposition is frequent and intense. Accessory Orthic Humo-Ferric Podzols and minor amounts of Eluviated Dystric Brunisols occur on unavalanched segments and are probably associated with veneers of altered medium textured eolian material (Eolian material B). A pedon illustrating Orthic Dystric Brunisols of the WH3 Ecosite is described in Table 389 and shown in Color Plate 88.

Table 389 Pedon (Alberta 1979 No. 41) description of an Orthic Dystric Brunisol of the WH3 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: WH3.

LOCATION: MILITARY GRID REF. 11 UU 9600 7625; NTS MAP AREA 83E 2E.

CLIMATE: 2010 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 11 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: VPH=LC9168HVTH=SE*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), COLLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: ACTIVE COLLUVIAL, AVALANCHED, BLANKET; SLOPE: 53% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING EAST, SITE AT UPPER SLOPE POSITION, LEVEL MICROTOPOGRAPHY,500 M LONG; SOIL MOISTURE AND DRAINAGE: SUBHUMID, RAPIDLY DRAINED, RAPIDLY PERVIOUS, VERY RAPID SURFACE RUNOFF, SEEPAGE ABSENT; EXCESSIVELY STONY.

SPECIAL NOTES: SSH=SC9662*APH=015-016*LFH=CB/YB/RI-A*

AH: 0 TO 8 CM, RANGE 6 TO 7 CM; MATRIX MOIST 10YR 3/2; LOAM; STRUCTURELESS STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE ROOTS; MANY, ABRUPT HORIZON BOUNDARY.

BM: 8 TO 41 CM, RANGE 32 TO 38 CM; MATRIX MOIST 10YR 5/3, MATRIX DRY 10YR 6/3; LOAM; WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, FINE ROOTS; COMMON, VERY FINE PORES; MANY, GRADUAL HORIZON BOUNDARY; STRONGLY ACID 5.1-5.5 FIELD PH.

BC1: 41 TO 86 CM, RANGE 40 TO 50 CM; MATRIX MOIST 10YR 4/4; LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; WEAK, FINE, GRANULAR SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, VERY FINE ROOTS; MANY, VERY FINE PORES; MANY, GRADUAL HORIZON BOUNDARY; STRONGLY ACID 5.1-5.5 FIELD PH.

BC2: 86 TO 120 CM; MATRIX MOIST 10YR 4/4; SANDY LOAM; MODERATE, FINE, GRANULAR STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, VERY FINE ROOTS; FEW, VERY FINE PORES; STRONGLY ACID 5.1-5.5 FIELD PH.

CHEMICAL DATA (SURVEY)

HORIZON		PH 1	ORG C (%)	BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
AH		5.0	14.10	51.3		18.8	4.7	-.1	1.3
BM		4.5	1.90	6.9		12.9	0.2	-.1	0.1
BC1		4.5		6.9		0.5	0.1	-.1	0.1
BC2		4.5		5.1		0.4	0.2	-.1	0.1

CHEMICAL DATA (SURVEY)

HORIZON		EXTRACT IRON (%) 1	2	EXTRACT ALUMINUM (%) 1	2
AH					
BM		0.2		0.1	
BC1					
BC2					

PHYSICAL DATA (SURVEY)

PARTICLE SIZE ANALYSIS

HORIZON		% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
AH						6	12	11	12	6	47		41	12	
BM						5	13	13	12	6	49		41	10	
BC1						11	11	10	10	5	47		43	10	
BC2		99	58	48	38	12	13	11	13	7	56		34	10	

PHYSICAL DATA

ENGINEERING

HORIZON		ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AH									
BM									
BC1									
BC2		34.0	41.0					25	83

This pedon was sampled in the upper Miette River valley in Jasper.

Vegetation

Vegetation distribution on the WH3 Ecosite is governed by the frequency and intensity of snow avalanching. Avalanche segments dominate and are characterized by a heterogeneous complex of v.t.s including subalpine fir-willow (S2), willow-dwarf birch-shrubby cinquefoil (S10), juniper-willow (L2), hairy wild rye-wild strawberry-fireweed (H5), fleabane-valerian (H16) plus intergrades. The most abundant and extensive v.t.s on WH3 are S2 and H16 but the other avalanche v.t.s occur occasionally. The heather-everlasting (L5) v.t. occurs in minor amounts. A plot illustrating the S2 v.t. of WH3 is described in Table 390 and shown in Plate 184 and represents the vegetation at the pedon sample site described above (Table 389).

Table 390 Stand (LC9168) illustrating the subalpine fir-willow (S2) v.t. of the WH3 Ecosite.

SHRUB LAYER	
Abies lasiocarpa	08
Salix barclayi	04
HERB-DWARF SHRUB LAYER	
Abies lasiocarpa	05
Agrostis variabilis	.5
Anemone occidentalis	10
Antennaria nitida	01
Arabis drummondii	.5
Arnica alpina	02
Artemisia norvegica	02
Carex limosa	05
Deschampsia caespitosa	01
Epilobium angustifolium	05
Phleum alpinum	01
Phyllodoce spp.	04
Poa arctica	02
Polygonum viviparum	.5
Potentilla spp.	.5
Pyrola spp.	.5
Senecio triangularis	03
Sibbaldia procumbens	.5
Thalictrum occidentale	06
Trisetum spicatum	.5
Valeriana sitchensis	06
Veratrum eschscholtzii	05
Veronica alpina	01
Salix arctica	05
Sedum divergens	02
Vaccinium caespitosum	02
Vaccinium membranaceum	04
Selaginella selaginoides	01
BRYOID LAYER	
Bryum spp.	01
Cladonia pyxidata	06
Ceratodon purpureus	03
Peltigera canina	.5
Peltigera spp.	03
Pogonatum alpinum	.5
Polytrichum juniperinum	02
Pseudoleskea radicosa	10
Solorina crocea	01
Barbilophozia hatcheri	02
Barbilophozia lycopodioides	02

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

Unavalanched or infrequently avalanched segments may constitute up to 50% of WH3 tracts and occur as forest strips between avalanche tracks and as patches along lower slopes fringing avalanche runout zones. The Engelmann spruce-subalpine fir/grouseberry (C15) and Engelmann spruce-subalpine fir/heather (O10) v.t.s dominate these segments. On a slope, C15 occurs below O10. The Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) and subalpine larch-subalpine fir/grouseberry-everlasting (C23) are important accessory v.t.s. The C21 v.t. replaces C15 in northern Jasper (north of the range of *Vaccinium scoparium*). Also, C23 occurs in southern Banff both on unavalanched, forested strips and as a stunted variant on avalanche path margins.

Unvegetated portions associated with rubbly colluvium and Regosolic soils in intensely active sites may constitute up to 50% of WH3 tracts, or up to 80% of WH3+T or WH3+CR tracts.

Discussion

In terms of landform surface expression, physiographic position, and vegetation cover, WH3 resembles the Wildflower 2 (WF2) and Endless Chain 2 (EN2) Ecosites. However, unlike the Colluvium B of WH3, WF2 occurs on colluvial landforms consisting of calcareous, medium textured colluvium (Colluvium C) and EN2 occurs on noncalcareous, coarse textured colluvium (Colluvium A). Also, WF2 has Eutric, occurs on noncalcareous, coarse textured colluvium (Colluvium A). Also, WF2 has Eutric, rather than Dystric, Brunisols and EN2, like WH3, has Dystric Brunisols but both sola and Ae horizons of the former are thicker. The other WH Ecosites are separated from WH3 primarily by vegetational differences (Table 385) that reflect varying type and degree of colluvial activity. The Fairview 1 (FV1) Ecosite occurring on noncalcareous, medium textured colluvium (Colluvium B) is the Lower Subalpine counterpart to WH3.

WH5 - WHITEHORN 5 ECOSITE

Ecosite Concept

The Upper Subalpine Ecosite, WH5, encompasses blankets and veneers of noncalcareous, medium textured colluvium (Colluvium B) overlying inclined bedrock on steep valley walls. Exposed bedrock escarpments are subdominant. Colluviation, in the form of surface or soil creep, is characteristic and influences soil and vegetation development. A soil pattern, in which Orthic Dystric Brunisols are dominant and Orthic Regosols are subdominant, typifies WH5. A vegetation pattern, in which the Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) v.t. is dominant and the Engelmann spruce-subalpine fir/heather (O10) v.t. is subdominant, is characteristic. Distribution of these v.t.s reflects elevational differences and varying degrees of colluvial activity and moisture status.

Geomorphology

The WH5 Ecosite occurs on shallow discontinuous colluvial landforms comprised of noncalcareous, medium textured colluvium (Colluvium B). Exposed bedrock escarpments are subdominant. Underlying and exposed bedrock is predominantly Miette Group or noncalcareous Mesozoic strata. Geomorphic activity on WH5 primarily consists of shallow colluviation of varying intensity across the landscape. Avalanching and related processes also occur (mapped as WH5A where 20 to 50% of the landscape is affected) but usually in channeled tracks. Sheet erosion is exten-

Table 391 Pedon (Alberta 1977 No. 125) description of an Orthic Regosol of the WH5 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1970, SUBGROUP: ORTHIC REGOSOL. SOIL MAP UNIT: NOTATION: WH5.

LOCATION: MILITARY GRID REF. 11 UBH 4030 2390; NTS MAP AREA 82N 9W.

CLIMATE: 2220 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS [illegible] DEG(C) AT 50 CM IN AUGUST.

[illegible]ION: VPN=AW7105*VTN=H20*.

SOIL SITE: PARENT MATERIAL 1: FRACTURED WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), MEDIUM ACID TO NEUTRAL (PH 5.6-7.3), COLLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: COLLUVIAL, ERODED(CHANNELLED), BLANKET; SLOPE: 68% SIMPLE SLOPE OF CLASS 8 (46-70%), FACING SOUTH, SITE AT LOWER SLOPE POSITION, 1000 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, VERY RAPID SURFACE RUNOFF, SEEPAGE ABSENT; VERY STONY; VERY ROCKY; HUMUS-FORM: MULL.

SPECIAL NOTES: SSN=GC7050*APH=783-095*RLU=15*PCF=75L(2)*LFH=CB/RI*

LH: 7 TO 0 CM, RANGE 0 TO 10 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/2; ABUNDANT, FINE AND COARSE ROOTS; ANGULAR GRAVELLY AND CHANNERY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

C: 0 TO 20 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/4; VERY GRAVELLY LOAM; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; ABUNDANT, FINE AND MEDIUM ROOTS; ANGULAR GRAVELLY AND CHANNERY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LH	5.5	45.70						
C	6.2	2.68	15.3		12.6	1.9	0.1	0.3

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LH														
C	99	87	17	5						43		45	12	1

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LH								
C	41.0	51.0					25	82

sive but of minor consequence, whereas locally, stream erosion in avalanched couloirs is more important to soil and vegetation development. Veneers of altered, medium textured eolian material (Eolian material B) occur sporadically, associated with stable sites. Rubble lacking fine earth material for soil development is common on some WH3 tracts, particularly those occurring below steep bedrock walls.

Topographically, WH5 displays long, linear, inclined slopes commonly ranging from 45 to >100%. These slopes consist of discontinuous colluvial veneers and blankets broken by patches of exposed bedrock. Tracts mapped as WH5 with complex topography have linear slopes whose continuity is broken by one or more exceptionally steep bedrock escarpments. On WH5X tracts, shallow materials characterized by colluvial veneers are dominant. Tracts mapped as WH5A often have couloirs that act as avalanche tracks, avalanche starting zones and associated intermittent stream channels. Tracts mapped as WH5F are failed.

Soils

Soils of the WH5 Ecosite are distributed in a pattern reflecting degree and intensity of surface colluviation and, to a lesser extent, avalanching. Orthic Dystric Brunisols are dominant and reflect weak but sufficient surface modification by erosion and/or deposition to retard or destroy eluvial (Ae) horizon development. Orthic Regosols are subdominant and occur on portions where geomorphic activity is frequent and intense.

Soils of the WH5 Ecosite are rapidly to well drained and reflect, in their development, the acidic, medium textured parent material. The Brunisolic soils have moderately to strongly developed B horizons. The Orthic

Regosols may have thin Ah horizons. Accessory Orthic Humo-Ferric Podzols and Eluviated Dystric Brunisols occur on stable sites. Lithic phases of WH3 soils are common. Orthic Sombric Brunisols occur in minor amounts. A pedon illustrating Orthic Regosols of the WH5 Ecosite is described in Table 391 and shown in Color Plate 89. This pedon was sampled on a south facing slope between Helen Creek and Bow Lake in Banff.

Vegetation

Vegetation of the WH5 Ecosite is distributed in a pattern reflecting degree of colluvial activity, drainage and elevation. The Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) v.t. is dominant and favors the more active, subxeric sites on southerly aspects. The Engelmann spruce-subalpine fir/heather (O10) v.t. is subdominant and occurs more extensively at higher elevations and on less active sites. An open variant of the subalpine larch-subalpine fir/grouseberry-everlasting (C23) v.t. occurs as an accessory on some WH5 tracts in southern Banff. The Engelmann spruce-subalpine fir/grouseberry (C15) and Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) v.t.s occur in minor amounts on less active sites. The Engelmann spruce-subalpine fir/valerian-fleabane (O9) and heather-everlasting (L5) v.t.s also occur in minor amounts.

Unvegetated portions and sparsely vegetated portions with the spotted saxifrage-hairy wild rye (H20) v.t. are associated with rubbly colluvium and Regosolic soils on intensely active sites and may constitute up to 50% of WH5 tracts. A plot illustrating the spotted saxifrage-hairy wild rye (H20) v.t. on an actively colluviating site on WH5 is described in Table 392 and shown in Plate 185 and represents the vegetation at the pedon sample site described above in Table 391.

Discussion

In terms of landform surface expression, physiographic position and vegetation cover, WH5 resembles the Wildflower 3 (WF3) and Endless Chain 3 (EN3) Ecosites. However, unlike the Colluvium B of WH5, WF3 occurs on colluvial landforms consisting of calcareous, medium textured colluvium (Colluvium C) and EN3 occurs on noncalcareous, coarse textured colluvium (Colluvium A). Also, WF3 has Eutric,

Table 392 Stand (AW7105) illustrating spotted saxifrage-hairy wild rye (H20), a v.t. occurring in minor amounts on actively colluviating portions of the WH5 Ecosite.

	HERB-DWARF SHRUB LAYER
Achillea millefolium	.5
Anemone multifida	.5
Antennaria nitida	.5
Carex xerantica	.5
Epilobium angustifolium	.5
Erigeron aureus	.5
Festuca saximontana	.5
Fragaria virginiana	.5
Hordeum jubatum	.5
Juniperus communis	02
Penstemon lyallii	02
Poa cusickii	.5
Saxifraga bronchialis	03
Solidago multiradiata	.5
Trisetum spicatum	01
	BRYOID LAYER
Polytrichum juniperinum	.5
Tortula ruralis	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0.5 INDICATES THE SPECIES WAS PRESENT

rather than Dystric, Brunisols and EN3, like WH5, has Dystric Brunisols but with thicker sola and well developed Ae horizons. Other WH Ecosites are separated from WH5 primarily by vegetation differences (Table 385) that reflect varying types and degrees of colluvial activity.

WW - WARWICK ECOSECTION

The Warwick Ecosection is characterized by calcareous, medium textured till (Till C) in the Lower Subalpine portion of the Subalpine Ecoregion with Regosolic soils and herb mat vegetation. It is distributed near the Continental Divide in association with retreating valley glaciers fed by larger icefields from the Freshfield Icefield in northwestern Banff to the Resthaven Icefield in extreme northwestern Jasper. The Warwick Ecosection concept is illustrated in Fig. 55 and summarized in Table 393. Age gradients are important within the incipient features of this landscape. Only one Ecosite (WW1) is recognized.

WW1 - WARWICK 1 ECOSITE

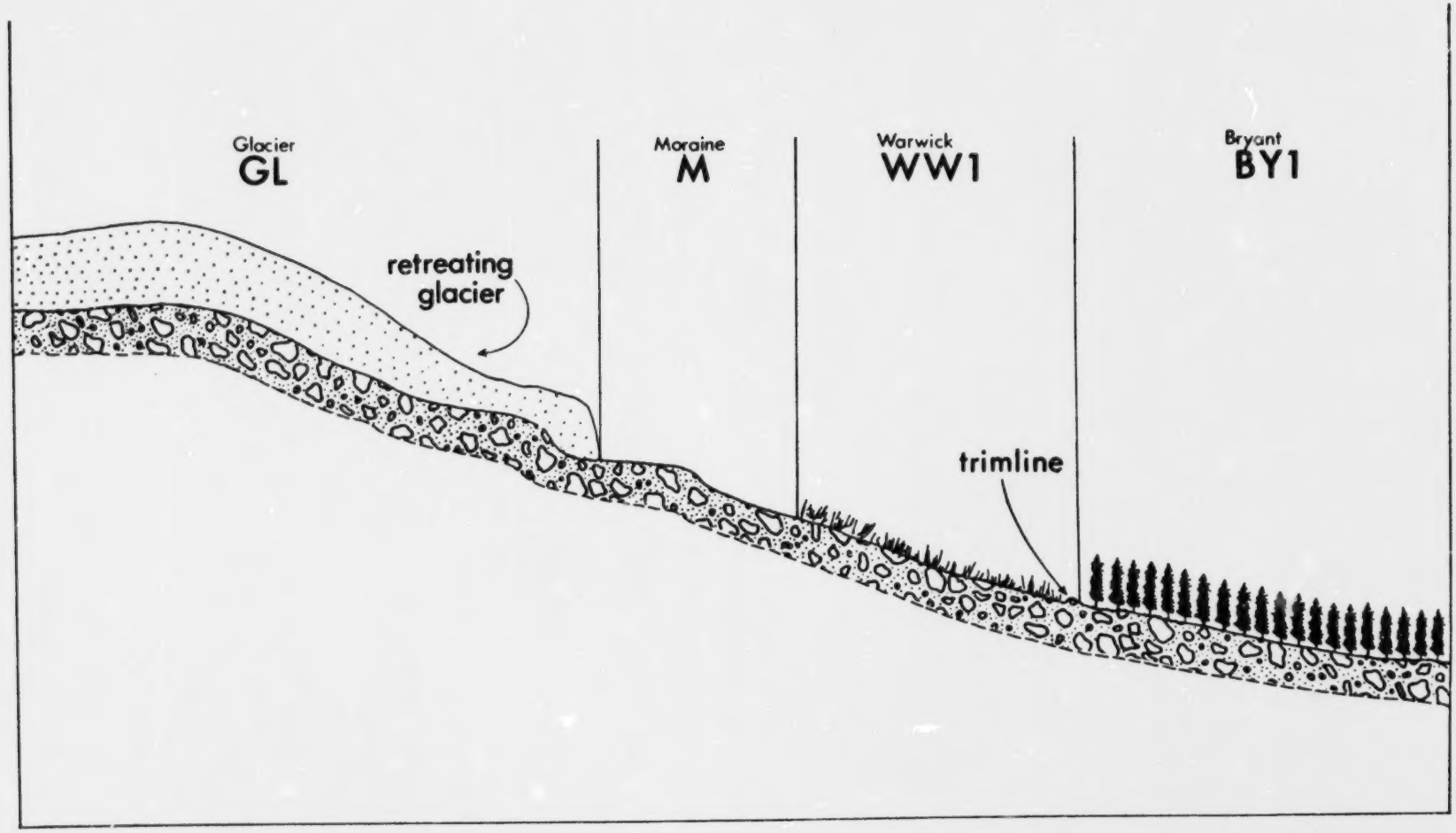
Ecosite Concept

The Warwick 1 Ecosite is characterized by hummocky and ridged calcareous, medium

Table 393 General features of the Warwick 1 (WW1) Ecosite.

Ecosite	Landform	Soils	Vegetation
WW1	Till C; hummocky, ridged	Regosolic	herb mat

Figure 55 Landscape schematic showing the relationship of the Warwick 1 (WW1) Ecosite to other Ecosites.



textured till (Till C) in the Lower Subalpine. Ice retreat from these areas is so recent that little soil development has occurred (Orthic Regosol, Orthic Humic Regosol), but yellow dryad-willow herb (H8) vegetation is established.

Geomorphology

Calcareous, medium textured till (Till C) is the genetic material of the Warwick 1 Ecosite. It is typically a valley bottom and lower slopes unit since the landforms have been generated by valley glaciers. Moraines representing a static ice margin have a ridged surface expression, while the general valley floor often is hummocky. Calcareous, variably textured ice contact stratified drift (Ice Contact Stratified Drift B) is an occasional associate, e.g. eskers occur near Southeast Lyell Glacier in Banff. On lower valley walls, the till surface form is blanket, sometimes gullied, over previously deposited till or inclined bedrock. Proglacial fluvial features frequently dissect the valley floor, a product of melt from the associated icefield.

Soils

The strongest influence on the soils of the Warwick 1 Ecosite is the time since glacial retreat. Despite the present surface stability, pedogenic processes have had little effect on the highly calcareous materials, thus soils are Regosolic. Most evident is incorporation of decomposing herb mat material into the surface mineral horizon, probably by both physical and chemical methods. Orthic Regosols reflect less of this activity, while Orthic Humic Regosols suggest more development through their deeper Ah horizons. Table 394 and Color Plate 90 illustrate soils of the Warwick 1 Ecosite.

Associated unvegetated portions of the landscape may show virtually no soil development.

Table 394 Pedon (Alberta 1978 No. 103) description of an Orthic Humic Regosol of the WW1 Ecosite.

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1976, SUBGROUP: ORTHIC HUMIC REGOSOL. SOIL MAP UNIT: NOTATION: WW1.

LOCATION: MILITARY GRID REF. 11 UNH 210 5020; NTS MAP AREA 82N 15W.

CLIMATE: 1540 METERS ABOVE MEAN SEA LEVEL. SOIL TEMP READING NO. 1 WAS 6 DEG(C) AT 50 CM IN OCTOBER.

VEGETATION: VPN=PA8169*VTN=H08+ SPRUCE TREES*.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL), LIMESTONE; LANDFORM CLASSIFICATION: MORAINAL, HUMMOCKY; SLOPE: 26% COMPLEX SLOPE OF CLASS 6 (16-30%), FACING SOUTH, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,75 M LONG; SOIL MOISTURE AND DRAINAGE: MODERATELY WELL DRAINED, SLOWLY PERVIOUS, SLOW SURFACE RUNOFF, SEEPAGE ABSENT; EXCEEDINGLY STONY; NONROCKY.

SPECIAL NOTES: SSN=BW8150*APN=015-46*RLU=15*SSC=CB+ST*PCF=4GR,2CB,1ST(2-3)*LOWER CK MOIST TO WET BUT NO EVIDENCE OF MOTTLES* HORIZON BOUNDARY.

L: 4 TO 0 CM, RANGE 3 TO 5 CM; HORIZON MOIST; MATRIX MOIST 10YR 2/2; PLENTIFUL, MICRO AND MEDIUM AND COARSE ROOTS; SMOOTH, ABRUPT

AHK: 0 TO 10 CM, RANGE 9 TO 11 CM; HORIZON MOIST; MATRIX MOIST 10YR 3/1; SANDY LOAM; VERY WEAK, FINE, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE AND FINE ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 40% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

CK: 10 TO 65 CM; HORIZON MOIST; MATRIX MOIST 5; 5/1; LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY WEAK, MEDIUM, SUBANGULAR BLOCKY SECONDARY STRUCTURE PSEUDO; FRIABLE CONSISTENCE; VERY FEW, MICRO AND VERY FINE ROOTS; FEW, MICRO PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 40% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
L	7.1	25.30	19.2
AHK	7.2	1.90	59.0
CK	7.8	0.50	71.0

PHYSICAL DATA (SURVEY)

		% PASSING				PARTICLE SIZE ANALYSIS										
												% OF SAMPLE				
HORIZON		3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
L																
AHK																
CK		99	95	73	57	20 6	21 8	15 7	12 8	5 5	73 34		24 48	3 18		2.20

PHYSICAL DATA

		MOISTURE STATUS (%)					ENGINEERING							
HORIZON		0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
L														
AHK			11.6	7.2										
CK			14.2	5.6			10.0	14.0					40	16

Topographic lows within the irregular landscape occasionally have Gleyed Regosols or Rego Gleysols, but drainage is consistently good on upland positions.

Vegetation

Time since glacial retreat from this landscape is the most influential factor in vegetation development on WW1. The yellow dryad-willow herb (H8) vegetation type is the consistently recognized community pioneering on these neoglacial landscapes.

Vegetation on this Ecosite varies from the H8 concept by the absence of willow herb except on infrequent poorly drained situations. Cover of Engelmann spruce on the oldest terrain may approach that of an open forest. The illustrated vegetation site (Table 395, Plate 186) demonstrates this variation.

Table 395 Stand (PA8169) illustrating the yellow dryad-willow herb (H8) v.t. of the WW1 Ecosite.

TREE LAYER	
Pseudotsuga menziesii	.5
TALL SHRUB LAYER	
Picea engelmannii	15
Pseudotsuga menziesii	.5
SHRUB LAYER	
Picea engelmannii	05
Salix glauca	.5
HERB-DWARF SHRUB LAYER	
Dryas drummondii	75
BRYOID LAYER	
Ceratodon purpureus	.5
Drepanocladus uncinatus	.5
Tortula norvegica	.5

VALUES ARE PERCENT COVER EXCEPT FOR EPIPHYTES WHERE 0 5 INDICATES THE SPECIES WAS PRESENT.

Discussion

The WW1 Ecosites are restricted to the Main Ranges where higher elevations and precipitation support icefields. Thus, sediment source is invariably Paleozoic carbonates and calcareous clastics of the Main Ranges upper stratigraphic column.

Heusser (1956) discusses several of the areas identified herein as WW1 and their relationships to surrounding landscapes. His work shows that WW1 landscapes may be as young as ten years and as old as four hundred years. Any given WW1 tract will span a considerable portion of this age range with youngest portions near the glacier, grading to oldest around the trimline that marks maximum recent glacial advance.

Both soil and vegetation development follow this same gradient. Near the glacier, soils demonstrate virtually no development except the presence of a few roots. Vegetation is patchy and restricted to a very few pioneer species such as *Dryas drummondii*. Intermediate aged areas are most extensive, and have characteristics as described in the Ecosite concept. Oldest, peripheral areas have soils that may show evidence of weathering of carbonates, but are still Regosolic. Vegetation species richness is increased to include small areas of the shrub and forest seral stages mentioned by Heusser (1956).

The boundaries between WW1 and other landscapes can be precisely located where they correspond with the trimline of the associated glacier. Landscapes that resemble WW1 are all found in similar neoglacial areas. Pipestone 4 (PP4) has similar soils and vegetation, but is found on glaciofluvial rather than till deposits. These are sorted (coarse), restricted to valley bottom positions, may occur beyond the trimline, and do not demonstrate well the age gradient discussed earlier. The Miscellaneous Landscapes Recent Moraine (M) and Stream Channel (SC) are distinguished by their virtual lack of soil and vegetation development. Also, the latter are fluvial and glaciofluvial deposits. The landscape M occurs in close proximity to the glacier. Where these neoglacial landscapes form a complex pattern, they are mapped as WW1 + M, with a majority of the nonvegetated M nearest the glacier, or WW1 + SC where active nonvegetated stream channels pass through the stable till area. Areas of bedrock scraped clean of surficial deposits and surrounded by stable till are mapped as WW1 + R.

Because aging of the dynamic features is possible, areas of WW1 are ideal for research purposes in such fields as glacial geology, geomorphology, paleoclimatic studies, soil genesis, vegetation succession, and naturally disturbed site rehabilitation.

ECOSITE MODIFIERS

A - AVALANCHED

The Ecosite Modifier Avalanched (A) is used on a map symbol when 20 to 50% of a tract is modified by frequent snow avalanche activity, and where the modification is not an integral part of the Ecosite concept. This modifier is used on many Ecosites of the Lower Subalpine and Upper Subalpine. A discussion of avalanche processes and terminology is provided by Perla and Martinelli (1975). Avalanching affects mainly vegetation and to a lesser extent soils. The v.t.s commonly found on avalanche paths include subalpine fir-willow (S2), willow-dwarf birch-shrubby cinquefoil (S10), juniper-willow (L2), hairy wild rye-wild strawberry-fireweed (H5), fleabane-valerian (H16) and where avalanches are infrequent, aspen/hairy wild rye-showy aster (C22). Plate 187 shows avalanche paths modifying a landscape in the Arctomys Creek Valley in Banff.

B - BURNED

The Ecosite Modifier Burned (B) is used when 50% or more of the vegetation of a tract is modified by fire and is indiscernible as a recognized v.t. (Plate 188). This modifier is used with most Ecosites in the Montane and Subalpine Ecoregions. In some cases, forested areas have been changed to recognized grassland or shrubland v.t.s; hence a change in Ecosite but modifier B is not used (e.g. Tyrrell Creek in Banff). Plate 188 shows a burned landscape near Vermilion Pass in Banff. Plate 189 shows a burned landscape near Mount Brewster in Banff.

F - FAILED

The Ecosite Modifier Failed (F) is of three types. The first encompasses old (inactive) rock glaciers that originated as talus and protalus ramparts below rock walls. The second type encompasses slow mass movement, often rotational, of unconsolidated material or bedrock plus mantle downslope, guided by a slip surface (Plate 190). Such failed slopes are postglacial and, in some instances, may still be active (Plate 190). The third type encompasses deep, extensive and severe solifluction that has created prominent solifluction benches on a slope. The modifier F is used with some Ecosites in the Subalpine and Alpine Ecoregions. This definition elaborates upon the one provided by the Canada Soil Survey Committee (C.S.S.C. 1978b).

X - LITHIC

The Ecosite Modifier Lithic (X) is added to a map when 50% or more of a tract is modified by a lithic layer and lithic phase soils are not an integral part of the Ecosite concept. A lithic layer is a consolidated bedrock layer within the control section below a depth of 10 cm (C.S.S.C. 1978b). The control section of most mineral soils in Banff and Jasper extends to a depth of about 1 m. Even though lithic phase soils dominate X-modified tracts, bedrock outcrops are not necessarily abundant.

Ecosite symbols modified by X occur in all Ecoregions. Plate 191 shows a lithic landscape mapped as PL4X in the Sunset Pass area of Banff.

MISCELLANEOUS LANDSCAPES

CL - COLLUVIAL LANDSLIDE

The Miscellaneous Landscape Colluvial Landslide (CL) consists of post and supraglacial landslide materials. These materials were deposited by the rapid gravity-induced movement (often along a guiding slip surface) of detached segments of bedrock plus mantle from pre-existing structural features upslope. Scars above mark the sites from which the material was detached. Structural deformation of the descended masses is characteristic. These deposits are comprised of a chaotic, generally loose, mixture of soil and rubble. They have originated from a variety of noncalcareous and calcareous bedrock strata. Surface expression is irregular, usually hummocky.

Tracts mapped as CL occur in all Ecoregions except the Montane. Nonsoil dominates the rubbly landscape. Regosolic soils occur locally and are associated with fine earths formed in situ by weathering and transported with the landslide, or deposited by wind and water processes. Tracts mapped as CL are sparsely vegetated with vegetation cover occupying less than 20% of the tract, although saxicolous lichen H12 may occupy >20% of some tracts. Recognized v.t.s that occur include saxicolous lichen (H12), spotted saxifrage-hairy wild rye (H20) and, at higher elevations, mountain avens-snow willow-moss campion (H1). Trees occur sporadically on some CL tracts.

The Miscellaneous Landscape CL is characterized by > 80% unvegetated terrain which distinguishes it from the IB or BP Ecosections, both of which characteristically contain >50% vegetated terrain. Tracts with 50 to 80% unvegetated terrain are mapped as, for example, IB2+CL. Plate 192 shows a tract mapped as CL above Baker Creek in Banff.

CR - COLLUVIAL RUBBLE

The Miscellaneous Landscape Colluvial Rubble (CR) consists of Colluvium A, B, or C, de-

pending on the characteristics of the bedrock from which it was derived. Physical weathering (joint block separation) of highly jointed bedrock, followed by slow gravity induced movement, produces colluvial rubble. This process is less prominent in resistant, massive quartzites, limestones, and dolostones. Slow displacement of material downslope is caused by surface creep, solifluction and sheet erosion.

Colluvial Rubble (CR) occurs in all Ecoregions except the Montane. Nonsoil dominates CR tracts. Regosolic soils occur locally and are associated with fine earths formed in situ by weathering, transported with surface creep or deposited by wind and water processes. Tracts mapped as CR may be unvegetated or sparsely vegetated. Recognized v.t.s such as saxicolous lichen (H12) and mountain avens-snow willow-moss campion (H1) occur only in patches and occupy less than 20% of a tract.

The Miscellaneous Landscape CR is most often complexed with the Miscellaneous Landscape Rockland (R). Also, CR is mapped as a complex with Ecosections associated with colluvial landforms when tracts contain 20 to 80% CR (e.g. WF2+CR), depending on the Ecosite definition. Plate 193 shows a CR tract near Tangle Ridge in Jasper. Note surface creep on the upper slope.

GL - GLACIER

The Miscellaneous Landscape Glacier (GL) includes glacier, firn, ice field and glacierette. Tracts mapped as GL occur in all Ecoregions except the Montane. It is most abundant in the Upper Subalpine and Alpine. Occurrences of GL in the Lower Subalpine are in the form of glacial tongues. Most GL tracts are distributed near the Continental Divide where precipitation is highest (Janz and Storr, 1977). A comparison of Price and Mountjoy (1970a) and Mountjoy (1980) with Falconer et al.(1966) reveals a positive correlation between GL occurrences and strata of the upper stratigraphic column of the Main Ranges. Occurrence and extent of GL is limited in the Front Ranges.

The GL landscape is unvegetated and nonsoil. In some cases, colluvial and landslide debris mantle glaciers (e.g. Wenkchemna Glacier). Occasionally, GL is mapped as a complex with other Miscellaneous Landscapes including Recent Moraine (M), Talus (T), and Rockland (R). Fig. 55 shows the relationship between GL and other segments of the landscape. Plate 194 shows a tract mapped as GL on Mt. Wilson in Banff.

M - RECENT MORAINE

The Miscellaneous Landscape Recent Moraine (M) is comprised primarily of calcareous, medium textured till (Till C) and occurs in the Subalpine and Alpine Ecoregions. It is frequently distributed near the Continental Divide in association with retreating valley glaciers. Ice retreat from these areas is so recent that Regosols and nonsoil are characteristic. Associated unvegetated portions show virtually no soil development. The yellow dryad-willow herb (H8) v.t. is the usual community pioneering these neoglacial landscapes. Regosolic soils with little horizon development are commonly found under these vegetated patches. Tracts mapped as M are found in close proximity to glaciers. Where M occurs in small patches, it is occasionally mapped as a complex (20 to 80% of the landscape) with other Miscellaneous Landscapes such as Glacier (GL) and Rockland (R). It is also mapped as a complex with the successionally related Warwick 1 (WW1) Ecosite (e.g. WW1+M). Fig. 55 shows the relationship of M to other segments of the landscape. Plate 195 shows a Recent Moraine (M) on the north side of Mount Strahan in Banff.

P - PITS

The Miscellaneous Landscape Pits (P) identifies localities where unconsolidated and consolidated materials are displaced by processes that are not part of a natural ecosystem. These include borrow pits and fills along transportation corridors, gravel pits, quarries and refuse disposal sites. Because of the small size and 1:50,000 map scale, many small disturbed sites are not shown cartographically.

R - ROCKLAND

The Miscellaneous Landscape Rockland (R) is comprised of consolidated bedrock of all lithologies and occurs in all Ecoregions of Banff and Jasper. Rockland is more abundant on resistant than recessive rock and is dominantly nonsoil and unvegetated. Some tracts are sparsely vegetated with characteristic v.t.s such as saxicolous lichen (H12) and mountain avens-snow willow-moss campion (H1). The H12 v.t commonly occurs at higher elevations in the Alpine Ecoregion. Some R tracts have stunted trees growing in cracks and shallow pockets of soil. Occasionally, R is mapped as a complex with Ecosites when >20% of a tract is dominated by exposed bedrock (e.g. WF2+R). Tracts mapped as R+CR are the most frequently occurring. In these situations, R can occupy between 20 and 80% of a tract. Glacier (GL) and Talus (T) are other Miscellaneous Landscapes occasionally mapped as complexes with R. Plate 196 shows R+GL near Bush Pass in Banff and Plate 197 shows R bordering the Snaring River valley in Jasper.

RG - ROCK GLACIER

The Miscellaneous Landscape Rock Glacier (RG) consists of a mass of poorly sorted, angular coarse fragments and fine earth material cemented by interstitial ice a meter or more below the surface. The Miscellaneous Landscape RG is a product of colluvial and glacial processes. Material is fed from talus slopes in cirques or along valley sides (protalus ramparts). The surface of RG is marked by concentric banding and wave forms suggestive of slow flow. These forms probably result from a combination of flow and melting of interstitial or underlying ice. The Miscellaneous Landscape RG is dominantly nonsoil and unvegetated. Regosols occur on older portions where vegetation has become established. Rock Glaciers are most abundant in the Main Ranges (Luckman and Crockett 1978). Most tracts mapped as RG occur in the Upper Subalpine and Alpine; a few RG units are mapped in the Lower Subalpine. Rock Glacier is often mapped as a complex with Talus (T) (e.g. T+RG). Plate 198 shows an RG tract near South Pass in Jasper.

SC - RECENT STREAM CHANNEL

The Miscellaneous Landscape SC encompasses level floodplains comprised primarily of calcareous, coarse textured glaciofluvial material (Glaciofluvial material B) and occurs in all Ecoregions. It is characterized by Regosolic and Gleysolic soils associated with sparsely or unvegetated sites. Sedge-saxifrage (H3), yellow dryad-willow herb (H8), and willow/horsetail (S7) v.t.s occur in small, isolated patches. The majority of SC tracts are found near the Continental Divide in close proximity to retreating valley glaciers. These tracts are rapidly aggrading and originate from glacial meltwater streams. The heavy sediment load of these streams produces numerous, shifting, shallow channels (braided streams). Tracts mapped as, for example, PP4+SC are a complex association of 20 to 80% SC with the PP4 Ecosite. Where active nonvegetated stream channels pass through the neoglacial landscape of the Warwick 1 (WW1) Ecosite, it is mapped as WW1+SC. Also, SC is confined to active portions of stream and river channels where vegetation does not become established and erosion removes most of the fine earth (<2 mm) fraction. It may also be mapped as a complex with several of the fluvial landscapes when it occupies between 50 and 80% of a tract (e.g. HC4+SC). Plate 199 shows an SC landscape in the upper Athabasca River valley in Jasper.

T - TALUS

The Miscellaneous Landscape Talus (T) consists of a loose, angular, coarse fragment dominated phase of Colluvium A, B or C, depending on the lithology from which it was derived. Talus (T) is formed chiefly by gravitational falling (rockfalls), rolling or sliding of individual fragments dislodged by physical weathering from very steep resistant rock walls above. In some cases debris flow and avalanche processes also deposit and redistribute material (Gray 1972, Luckman 1972). Talus is expressed as steep, usually concave slopes in the form of cones, aprons, and fans. It is often generated by resistant rock and overlies recessive rock. The thickness of T diminishes from the bottom to the top of a slope with smaller sized fragments being more abundant near the top. The upper portion of a T slope is usually steeper than the lower portion. Material comprised of large fragments produces much steeper T slopes than does material made up of finer fragments.

Talus is dominantly nonsoil and unvegetated. A few tracts have Regosolic soils associated with sparse vegetation. Tracts mapped as T occur in all Ecoregions except the Montane. It is occasionally mapped with other Miscellaneous Landscapes such as Glacier (GL), Recent Moraine (M), and Rock Glacier (RG), when they occupy >20% of the landscape. Tracts mapped as T+GL encompasses T that is partially overlying ice on shaded slopes. Tracts mapped as T+M have pockets of M too small to delineate and also include M that has colluviated over the steep slopes that form the mouths of hanging valleys and cirques. Tracts mapped as T+RG encompass talus aprons plus their protalus ramparts in which interstitial ice is present. Even though formed by different processes, the two are linked because T provides material to the RG. Also mapped as a complex with T are several of the colluvial Ecosites when T occupies between 20 and 80% of a tract (e.g. SB1+T). Plate 200 shows a landscape mapped as T in the form of coalescing talus cones at the base of Mount Warwick in Jasper.

W - WATER BODIES

The Miscellaneous Landscape Water Bodies (colored blue on the map) includes named and unnamed lakes and named and unnamed ponds both natural and artificial. The 1:50,000 NTS maps used as base maps do not show all of the Water Bodies shown on the maps in this report, so these have been added to the base map information. The smallest Water Bodies shown on the maps are approximately 25 ha. Water Bodies are delineated at the high water level where seasonal fluctuations are evident. Water Bodies are mapped in all Ecoregions in Banff and Jasper. Plate 201 shows two Water Bodies in Banff above the confluence of Clearwater River and Roaring Creek.

APPENDIX A: PLANT CHECKLISTS

The following checklists are based primarily on collections made during the Ecological Land Classification of Banff and Jasper National Parks, 1974-1979. Nomenclature for vascular plants follow primarily Moss (1959) and Hitchcock and Cronquist (1973), for liverworts Stotler and Crandall-Stotler (1977), for mosses Crum et al. (1973), and for lichens Hale and Culbertson, (1970) and Hawksworth et al. (1980). In the checklists, a B following the taxon name indicates occurrence in Banff only and J occurrence in Jasper only; taxa with neither occur in both parks. Banff has a total of 844 vascular taxa, 187 moss taxa, 21 liverwort taxa, and 289 lichen taxa. Jasper has a total of 748 vascular taxa, 220 moss taxa, 48 liverwort taxa, and 351 lichen taxa. The total for both parks is 996 vascular taxa, 243 moss taxa, 53 liverwort taxa, and 407 lichen taxa.

LYCOPODIOPHYTA

ISOETACEAE

Isoetes muricata Dur., J

LYCOPODIACEAE

Lycopodium alpinum L.
Lycopodium annotinum L.
Lycopodium clavatum L.
Lycopodium complanatum L.
Lycopodium selago L.
Lycopodium sitchense Rupr.

SELAGINELLACEAE

Selaginella densa Rydb.
Selaginella rupestris (L.)Spring
Selaginella selaginoides (L.)Link

EQUISETOPHYTA

EQUISETACEAE

Equisetum arvense L.
Equisetum fluviatile L.
Equisetum hyemale L.
Equisetum laevigatum A.Br., B
Equisetum palustre L.
Equisetum pratense Ehrh.
Equisetum scirpoides Michx.
Equisetum sylvaticum L., J
Equisetum variegatum Schleich.

POLYPODIOPHYTA

OPHIOGLOSSACEAE

Botrychium boreale (E.Fries)Milde
Botrychium lanceolatum (Gmelin)Rupr. var. *lanceolatum*, J
Botrichium lunaria (L.)Sw.

POLYPODIACEAE

Asplenium viride Huds.
Athyrium alpestre (Hoppe)Rylands, J
Athyrium filix-femina (L.)Roth, B
Cheilanthes feei Moore, B
Cryptogramma crispa (L.)R.Br. var. *acrostichoides* (R.Br.)Clarke
Cystopteris fragilis (L.)Bernh.
Cystopteris montana (Lam.)Bernh., J
Dryopteris assimilis S. Walker
Dryopteris fragrans (L.)Schott, J
Dryopteris spinulosa (Muell.)Watt, J
Gymnocarpium dryopteris (L.)Newm.
Pellaea atropurpurea (L.)Link., B
Pellaea glabella Mett. var. *occidentalis* (E.Nels.)Butters
Polystichum lonchitis (L.)Roth
Pteridium aquilinum (L.)Kuhn var. *pubescens* Underw.
Thelypteris phegopteris L., J
Woodsia glabella R.Br., B
Woodsia oregana D.C.Eat.
Woodsia scopulina D.C.Eat.

PINOPHYTA

CUPRESSACEAE

Juniperus communis L.
Juniperus horizontalis Moench
Juniperus scopulorum Sarg., B

PINACEAE

Abies lasiocarpa (Hook.)Nutt.
Larix laricina (Du Roi)K.Koch, J
Larix lyallii Parl., B
Picea engelmannii Parry
Picea glauca (Moench)Voss
Picea mariana (Mill.)BSP.
Pinus albicaulis Engelm.
Pinus contorta Dougl. *ex* Loud.
Pinus flexilis James, B
Pseudotsuga menziesii (Mirb.)Franco
Thuja plicata D.Don, B
Tsuga heterophylla (Raf.)Sarg.

MAGNOLIOPHYTA

MAGNOLIATAE

ACERACEAE

Acer glabrum Torr.
Acer negundo L., B

APOCYNACEAE

Apocynum androsaemifolium L.

ARALIACEAE

Aralia nudicaulis L., J

BERBERIDACEAE

Mahonia repens (Lindl.)G.Don = *Berberis repens* Lindl., B

BETULACEAE

Alnus crispa (Ait.)Pursh ssp. *sinuata* (Regel)Hult.
Alnus tenuifolia Nutt., J
Betula glandulosa Michx.

Betula occidentalis Hook.
Betula papyrifera Marsh.
Betula pumila L. var. *glandulifera* Regel, B

BORAGINACEAE
Cryptantha affinis (A.Gray)Greene, B
Hackelia diffusa (Lehm.)Johnst., J
Hackelia floribunda (Lehm.)I.M.Johnston, B
Hackelia jessicae (McGreg.)Brand
Lappula echinata Gilib.
Lappula redowski (Hornem.)Greene, B
Lithospermum incisum Lehm.
Lithospermum ruderale Lehm., B
Mertensia paniculata (Ait.)G.Don
Myosotis alpestris Schmidt

CAMPANULACEAE
Campanula lasiocarpa Cham.
Campanula rotundifolia L.
Campanula uniflora L.

CAPRIFOLIACEAE
Linnaea borealis L.
Lonicera dioica L. var. *glaucescens* (Rydb.)Butters
Lonicera involucrata (Richards.)Banks
Lonicera villosa (Michx.)Roem. & Schult., J
Sambucus melanocarpa A.Gray, J
Sambucus pubens Michx.
Symphoricarpos albus (L.)Blake
Symphoricarpos occidentalis Hook.
Viburnum edule (Michx.)Raf.

CARYOPHYLLACEAE
Arenaria capillaris Poir., B
Arenaria dawsonensis Britt.
Arenaria humifusa Wahl., B
Arenaria lateriflora L.
Arenaria nuttallii Pax, J
Arenaria obtusiloba (Rydb.)Fern.
Arenaria rossii R.Br. (s.l.)
Arenaria rubella (Wahlenb.)J.E.Smith
Arenaria sajanensis Willd.
Cerastium arvense L.
Cerastium beeringianum Cham. & Schlect.
Cerastium vulgatum L. var. *hirsutum* Fries
Lychnis affinis J.Vahl, B
Lychnis apetala L.
Lychnis drummondii (Hook.)S.Wats., B
Sagina saginoides (L.)Karst., B
Silene acaulis L.
Silene cucubalus Wibel., B
Silene furcata Raf., J
Silene menziesii Hook., B
Silene parryi (S.Wats.)C.L.Hitchc. & Maguire, B
Stellaria americana Porter, J
Stellaria calycantha (Ledeb.)Bong.
Stellaria crassifolia Ehrh., B
Stellaria longipes Goldie
Stellaria monantha Hult., B
Stellaria umbellata Turcz., B

CHENOPODIACEAE
Chenopodium capitatum (L.)Aschers.
Chenopodium hybridum L., B
Chenopodium praericola Rydb., B
Corispermum hyssopifolium L., J
Monolepis nuttalliana (Schultes)Greene, B
Salsola kali L. var. *tenuifolia* Tausch, J

COMPOSITAE
Achillea millefolium L.
Agoseris aurantiaca (Hook.)Greene
Agoseris glauca (Pursh)Raf. var. *dasycephala* (Torr. & A.Gray)Jeps.
Anaphalis margaritacea (L.)Benth. & Hook.
Antennaria acuta Rydb., B
Antennaria alpina (L.)Gaertn. var. *media* (Greene)Jeps.
Antennaria angustata Greene
Antennaria corymbosa E.Nels.
Antennaria lanata (Hook.)Greene
Antennaria luzuloides Torr. & A. Gray
Antennaria monocephala DC. ssp. *monocephala*
Antennaria neglecta Greene
Antennaria nitida Greene
Antennaria parvifolia Nutt.
Antennaria pulcherrima (Hook.)Greene
Antennaria racemosa Hook.
Antennaria rosea Greene
Antennaria umbrinella Rydb.
Arnica alpina (L.)Olin ssp. *angustifolia* (Vahl)Maguire
Arnica alpina (L.)Olin var. *tomentosa* (Macoun)Cronq., B
Arnica amplexicaulis Nutt., B
Arnica cordifolia Hook.
Arnica diversifolia Greene
Arnica fulgens Pursh, J
Arnica gracilis Rydb., B
Arnica latifolia Bong.
Arnica lonchophylla Greene
Arnica louiseana Farr
Arnica mollis Hook.
Arnica parryi A.Gray
Arnica rydbergii Greene
Artemisia biennis Willd., J
Artemisia borealis Pall., J
Artemisia campestris L.
Artemisia dracunculus L.
Artemisia frigida Willd.
Artemisia ludoviciana Nutt.
Artemisia michauxiana Bess.
Artemisia norvegica Fries
Aster adscendens Lindl., B
Aster alpinus L.
Aster campestris Nutt., J
Aster ciliolatus Lindl.
Aster conspicuus Lindl.
Aster eatonii (A.Gray)Howell, B
Aster foliaceus Lindl.
Aster hesperius A.Gray, B
Aster junciformis Rydb.
Aster laevis L., B
Aster maccallae Rydb., B
Aster modestus Lindl., B
Aster occidentalis (Nutt.)Torr. & A. Gray, J
Aster puniceus L., B
Aster sibiricus L.
Chrysanthemum leucanthemum L.
Chrysopsis villosa (Pursh)Nutt., B
Cirsium arvense (L.)Scop.
Cirsium foliosum (Hook.)DC., B
Cirsium hookerianum Nutt.

Cirsium vulgare (Savi)Airy-Shaw, B
Crepis atrabarba Heller, B
Crepis elegans Hook.
Crepis intermedia A.Gray, B
Crepis nana Richards.
Crepis runcinata (James)Torr. & A.Gray, B
Crepis tectorum L., J
Erigeron acris L.
Erigeron aureus Greene
Erigeron caespitosus Nutt.
Erigeron compositus Pursh
Erigeron flagellaris A.Gray, J
Erigeron glabellus Nutt.
Erigeron grandiflorus Hook.
Erigeron humilus Grah.
Erigeron hyssopifolius Michx., J
Erigeron lanatus Hook.
Erigeron lonchophyllus Hook., B
Erigeron ochroleucus Nutt.
Erigeron pallens Cronq.
Erigeron peregrinus (Pursh)Greene
Erigeron philadelphicus L.
Erigeron pumilus Nutt., J
Erigeron scotteri Boivin, B
Erigeron speciosus (Lindl.)DC.
Erigeron subtrinervis Rydb., B
Erigeron trifidus Hook.
Erigeron uncialis Blake, J
Gaillardia aristata Pursh
Haplopappus lyallii A.Gray
Haplopappus uniflorus (Hook.) Torr. & A.Gray, B
Helianthus nuttallii Torr. & A.Gray, B
Hieracium albertinum Farr, B
Hieracium albiflorum Hook.
Hieracium canadense Michx., B
Hieracium gracile Hook.
Hieracium umbellatum L.
Lactuca pulchella (Pursh)DC., B
Matricaria matricarioides (Less.)Porter
Petasites palmatus (Ait.)A.Gray
Petasites sagittatus (Pursh)A.Gray
Petasites vitifolius Greene
Saussurea densa (Hook.)Rydb.
Senecio canus Hook.
Senecio cymbalarioides Nutt. = *S. debilis* Nutt.
Senecio fremontii Torr. & A. Gray
Senecio indecorus Greene
Senecio integerrimus Nutt. var. *exaltatus* (Nutt.)Cronq.
Senecio lugens Richards.
Senecio pauciflorus Pursh
Senecio pauperculus Michx.
Senecio pseudaureus Rydb., B
Senecio sphaerocephalus Greene, B
Senecio subnudus DC., J
Senecio triangularis Hook.
Senecio vulgaris L., B
Solidago canadensis L., B
Solidago decumbens Greene = *S. spathulata* DC.
Solidago missouriensis Nutt., B
Solidago multiradiata Ait.
Solidago nemoralis Ait., J
Solidago rigida L. var. *humilis* Porter, J
Sonchus arvensis L., J
Sonchus uliginosus Bieb., B
Taraxacum ceratophorum (Ledeb.) DC
Taraxacum laevigatum (Willd.)DC., B
Taraxacum lyratum (Ledeb.)DC.
Taraxacum officinale Weber
Tragopogon dubius Scop.

CORNACEAE
Cornus canadensis L.
Cornus stolonifera Michx.

CRASSULACEAE
Sedum divergens Wats., J
Sedum roseum (L.)Scop., B
Sedum stenopetalum Pursh = *S. lanceolatum* Torr.

CRUCIFERAE
Arabis divaricarpa A.Nels., J
Arabis drummondii A.Gray
Arabis glabra (L.)Bernh.
Arabis hirsuta (L.)Scop.
Arabis holboellii Hornem. var. *holboellii*
Arabis holboellii Hornem. var. *pendulocarpa* (A.Nels.)Rollins, J
Arabis holboellii Hornem. var. *retrofracta* (Graham)Rydb., J
Arabis lemmonii S.Wats.
Arabis lyallii S.Wats.
Arabis lyrata L.
Arabis microphylla Nutt., B
Arabis nuttallii Robinson
Armoracia rusticana Gaertn., B
Brassica campestris L., B
Brassica juncea (L.)Cosson, B
Braya glabella Richards., J
Braya humilis (C.A.Mey.)Robins.
Braya purpurascens (R.Br.)Bunge, J
Capsella bursa-pastoris (L.)Medic., B
Cardamine bellidifolia L.
Cardamine oligosperma Nutt. var. *kamtschatica* (Regel)Dett.
Cardamine pensylvanica Muhl.
Cardamine umbellata Greene, B
Descurainia pinnata (Walt.)Britt., B
Descurainia richardsonii (Sweet)O.E.Schulz, B
Descurainia sophia (L.)Webb, B
Draba albertina Greene
Draba alpina L., J
Draba aurea Vahl
Draba borealis DC.
Draba cana Rydb. = *D. lanceolata* Royle
Draba cinerea Adams, B
Draba crassifolia R.Grah.
Draba densifolia Nutt., B
Draba fladnizensis Wulfen, B
Draba glabella Pursh, J
Draba hirta L., J
Draba incerta Payson
Draba kananaskis G.A.Mulligan, J
Draba lonchocarpa Rydb. var. *lonchocarpa*
Draba longipes Raup
Draba macounii O.E.Schulz
Draba nemorosa L., B
Draba nivalis Liljebl.
Draba oligosperma Hook.
Draba paysonii Macbr.
Draba porsildii G.A.Mulligan, B
Draba praealta Greene

Draba reptans (Lam.)Fern., B
Draba stenoloba Ledeb.
Draba ventosa A.Gray
Erucastrum gallicum (Willd.)Schulz, J
Erysimum asperum (Nutt.)DC., J
Erysimum cheiranthoides L.
Erysimum inconspicuum (S.Wats.)MacM.
Erysimum pallasii (Pursh)Fern.
Lepidium densiflorum Schrad.
Lepidium ramosissimum A.Nels., B
Lesquerella alpina (Nutt.)S.Wats. var. *spathulata* (Rydb.)Payson, J
Lesquerella arctica Wormsk., B
Neslia paniculata (L.)Desv., B
Physaria didymocarpa (Hook.)A.Gray
Rorippa islandica (Oeder)Borbas
Rorripa nasturtium-aquaticum (L.)Schinz. & Thell., B
Rorippa obtusa (Nutt.)Britt., B
Sisymbrium loeselii L.
Smelowskia calycina (Stephan)C.A.Mey. var. *americana* (Rydb.)Drury & Rollins
Thlaspi arvense L.

DROSERACEAE
Drosera anglica Huds., J
Drosera linearis Goldie, B

ELAEAGNACEAE
Elaeagnus commutata Bernh.
Shepherdia canadensis (L.)Nutt.

EMPETRACEAE
Empetrum nigrum L.

ERICACEAE
Andromeda polifolia L., J
Arctostaphylos rubra (Rehder & Wils.)Fern.
Arctostaphylos uva-ursi (L.)Spreng.
Cassiope mertensiana (Bong.)D.Don
Cassiope tetragona (L.)D.Don
Gaultheria hispidula (L.)Bigel.
Gaultheria humifusa (Graham)Rydb.
Kalmia polifolia Wang. var. *microphylla* (Hook.)Rehd.
Ledum glandulosum Nutt., B
Ledum groenlandicum Oeder
Loiseleuria procumbens (L.)Desv., J
Menziesia glabella A.Gray = *M.ferruginea* J.E.Smith var. *glabella* (A.Gray)Peck
Oxycoccus microcarpus Turcz.
Phyllodoce empetriformis (Smith)D.Don
Phyllodoce glanduliflora (Hook.)Coville
Phyllodoce intermedia (Hook.)Camp
Rhododendron albiflorum Hook.
Rhododendron lapponicum (L.)Wahlenb., J
Vaccinium caespitosum Michx.
Vaccinium membranaceum Dougl.
Vaccinium myrtilloides Michx., J
Vaccinium myrtillus L.
Vaccinium ovalifolium J.E.Smith
Vaccinium scoparium Leiberg
Vaccinium uliginosum L., J
Vaccinium vitis-idaea L. var. *minus* Lodd

FUMARIACEAE
Corydalis aurea Willd.
Corydalis sempervirens (L.)Pers., J

GENTIANACEAE
Gentiana affinis Griseb., B
Gentiana amarella L.
Gentiana crinata Froel., B
Gentiana glauca Pall.
Gentiana propinqua Richards.
Gentiana prostrata Haenke var. *americana* Engelm.
Menyanthes trifoliata L.

GERANIACEAE
Geranium erianthum DC., J
Geranium richardsonii Fisch. & Trautv.
Geranium viscosisssimum Fisch. & Mey., B

HALORAGACEAE
Myriophyllum alterniflorum DC., B
Myriophyllum exalbescens Fern.

HIPPURIDACEAE
Hippuris montana Ledeb., J
Hippuris vulgaris L.

HYDROCHARITACEAE
Vallisneria americana Michx., B

HYDROPHYLLACEAE
Phacelia franklinii (R.Br.)A.Gray
Phacelia sericea (Graham)A.Gray
Romanzoffia sitchensis Bong., B

LABIATAE
Galeopsis tetrahit L.
Glecoma hederacea L., B
Mentha arvensis L. var. *villosa* (Benth.)R.S.Stewart
Prunella vulgaris L.

LEGUMINOSAE
Astragalus aboriginum Richards.
Astragalus agrestis Dougl. *ex* Hook. (=*A.dasyglottis* Fisch. *ex* DC.)
Astragalus alpinus L.
Astragalus bourgovii A.Gray, B
Astragalus decumbens (Nutt.)A.Gray var. *serotinus* (A.Gray)M.E.Jones
Astragalus eucosmus Robins.
Astragalus flexuosus (Dougl.)G.Don, B
Astragalus frigidus (L.)A.Gray var. *americanus* (Hook.)S.Wats.
Astragalus occidentalis (S.Wats.)M.E.Jones
Astragalus striatus Nutt.
Astragalus tenellus Pursh, J
Astragalus vexilliflexus Sheld.
Hedysarum alpinum L.
Hedysarum boreale Nutt., B
Hedysarum mackenzii Richards.
Hedysarum sulphurescens Rydb., B
Lathyrus ochroleucus Hook.
Lupinus nootkatensis Donn, J
Medicago lupulina L.
Medicago sativa L., B
Melilotus alba Desr.
Melilotus officinalis (L.)Lam., B
Oxytropis campestris (L.)DC.
Oxytropis deflexa (Pall.)DC.
Oxytropis podocarpa A.Gray
Oxytropis sericea Nutt. var. *spicata*

(Hook.)Barneby
Oxytropis splendens Dougl. *ex* Hook.
Oxytropis viscida Nutt., B
Thermopsis rhombifolia (Nutt.)Richards., B
Trifolium agrarium L., B
Trifolium hybridum L., B
Trifolium pratense L.
Trifolium repens L.
Vicia americana Muhl.
Vicia cracca L.

LENTIBULARIACEAE
Pinguicula vulgaris L.
Utricularia intermedia Hayne, B
Utricularia minor L.
Utricularia vulgaris L.

LINACEAE
Linum lewisii Pursh

LOBELIACEAE
Lobelia kalmii L.

LORANTHACEAE
Arceuthobium americanum Nutt.

NYMPHAEACEAE
Nuphar variegatum Engelm., J

ONAGRACEAE
Epilobium alpinum L.
Epilobium angustifolium L.
Epilobium clavatum Trel., J
Epilobium davuricum Fisch., B
Epilobium glandulosum Lehm.
Epilobium hornemannii Reichenb.
Epilobium lactiflorum Hausskn.
Epilobium latifolium L.
Epilobium leptophyllum Raf., B
Epilobium luteum Pursh, J
Epilobium palustre L., B
Epilobium [illegible]yphyllum Rydb., J

OROBANCHACEAE
Orobanche fasciculata Nutt.

PAPAVERACEAE
Papaver freedmanianum D.Löve, J
Papaver kluanensis D.Löve
Papaver nudicaule L.

PLANTAGINACEAE
Plantago canescens Adams, J
Plantago major L.
Plantago septata Morris

POLEMONIACEAE
Collomia linearis Nutt., B
Polemonium caeruleum L. ssp. *occidentale* (Greene)Davidson, J
Polemonium pulcherrimum Hook.

POLYGONACEAE
Ericgonum androsaceum Benth.
Eriogonum ovalifolium Nutt., B
Eriogonum piperi Greene, J
Eriogonum subalpinum Greene
Koenigia islandica L., J
Oxyria digyna (L.)Hill
Polygonum amphibium L. var. *stipulaceum* (Coleman)Fern.
Polygonum aviculare L., B
Polygonum bistortoides Pursh, J
Polygonum minimum S.Wats., B
Polygonum ramosissimum Michx., B
Polygonum viviparum L.
Rheum rhaponticum L., J
Rumex acetosella L.
Rumex alpestris (Scop.)Löve
Rumex crispus L., B
Rumex maritimus L. var. *fueginus* (Phil.)Dusen, B
Rumex mexicanus Meisn., B
Rumex occidentalis S.Wats. var. *fenestratus* (Greene)Le Page, B

PORTULACACEAE
Claytonia lanceolata Pursh
Claytonia megarrhiza (A.Gray)Parry, B

PRIMULACEAE
Androsace chamaejasme Host
Androsace septentrionalis L.
Dodecatheon conjugens Greene, B
Dodecatheon radicatum Greene
Primula egaliksensis Wormskj., J
Primula incana M.E.Jones, J
Primula mistassinica Michx.
Primula stricta Hornem., J

PYROLACEAE
Chimaphila umbellata (L.)Bart.
Moneses uniflora (L.)A.Gray
Pyrola asarifolia Michx.
Pyrola elliptica Nutt., B
Pyrola grandiflora Radius, J
Pyrola minor L.
Pyrola secunda L.
Pyrola virens Schweigg.

RANUNCULACEAE
Aconitum delphinifolium DC.
Actaea rubra (Ait.)Willd.
Anemone drummondii S.Wats.
Anemone multifida Poir.
Anemone occidentalis S.Wats.
Anemone parviflora Michx.
Anemone patens L. var. *wolfgangiana* (Bess.)Koch
Anemone richardsonii Hook., J
Aquilegia brevistyla Hook., B
Aquilegia flavescens S.Wats.
Aquilegia formosa Fisch., J
Aquilegia jonesii Parry, J
Caltha leptosepala DC.
Clematis verticellaris DC. var. *columbiana* (Nutt.)A.Gray
Delphinium bicolor Nutt., B
Delphinium depauperatum Nutt., B
Delphinium glaucum S.Wats.
Delphinium nuttallianum Pritz.
Ranunculus abortivus L., B
Ranunculus acris L.
Ranunculus aquatilis L., B
Ranunculus cardiophyllus Hook.
Ranunculus circinatus Sibth. var. *subrigidus*

(W.Drew)L.Benson, J
Ranunculus cymbalaria Pursh, B
Ranunculus eschscholtzii Schlecht.
Ranunculus flammula L. var. *filiformis* (Michx.)Hook.
Ranunculus gelidus Kar. & Kir., B
Ranunculus gmelinii DC. var. *hookeri* (D.Don)L.Benson, B
Ranunculus gmelinii DC. var. *limosus* (Nutt.)Hara, J
Ranunculus inamoenus Greene
Ranunculus natans C.A.Mey., J
Ranunculus nivalis L., J
Ranunculus occidentalis Nutt.
Ranunculus pedatifidus J.E.Smith var. *affinis* (R.Br.)L.Benson
Ranunculus pygmaeus Wahlenb., B
Ranunculus sceleratus L.
Ranunculus uncinatus D.Don var. *parviflorus* (Torr.)L.Benson, J
Ranunculus verecundus B.L.Robins.
Thalictrum occidentale A.Gray
Thalictrum venulosum Trel.
Trollius albiflorus (A.Gray)Rydb.

ROSACEAE
Amelanchier alnifolia Nutt.
Dryas drummondii Richards.
Dryas integrifolia M.Vahl
Dryas octopetala L. var. *hookeriana* (Juz.)Breit.
Fragaria virginiana Duchesne var. *glauca* S.Wats.
Geum allepicum Jacq. var. *strictum* (Ait.)Fern.
Geum macrophyllum Willd.
Geum rivale L.
Geum triflorum Pursh
Luetkea pectinata (Pursh)Kuntze
Potentilla anserina L.
Potentilla argentea L., J
Potentilla arguta Pursh, J
Potentilla concinna Richards., B
Potentilla diversifolia Lehm.
Potentilla drummondii Lehm., B
Potentilla fallax Porsild, B
Potentilla fruticosa L.
Potentilla glandulosa Lindl. ssp. *pseudorupestris* (Rydb.)Keck
Potentilla gracilis Dougl.
Potentilla hyparctica Malte
Potentilla ledebouriana Porsild
Potentilla macounii Rydb., B
Potentilla nivea L. ssp. *nivea*
Potentilla nivea L. ssp. *hookeriana* (Lehm.)Hiitonen (= *P. hookeriana* Lehm.), B
Potentilla norvegica L.
Potentilla ovina Macoun., B
Potentilla palustris (L.)Scop.
Potentilla pensylvanica L.
Potentilla plattensis Nutt., B
Potentilla quinquefolia Rydb., B
Potentilla rivalis Nutt., J
Potentilla uniflora Ledeb.
Potentilla villosa Pall. *ex* Pursh
Prunus pensylvanica L.f.
Prunus virginiana L.
Rosa acicularis Lindl.
Rubus acaulis Michx.
Rubus chamaemorus L., J
Rubus melanolasius Focke, B
Rubus parviflorus Nutt., J
Rubus pedatus J.E.Smith
Rubus pubescens Raf.
Rubus strigosus Michx., J
Sibbaldia procumbens L.
Sorbus scopulina Greene
Sorbus sitchensis Roemer
Spiraea alba DuRoi, B
Spiraea lucida Dougl.

RUBIACEAE
Galium boreale L.
Galium palustre L.
Galium trifidum L.
Galium triflorum Michx.

SALICACEAE
Populus balsamifera L.
Populus tremuloides Michx.
Salix alaxensis (Anderss.)Coville, J
Salix arbusculoides Anderss.
Salix arctica Pall.
Salix athabascensis Raup, J
Salix barclayi Anderss.
Salix barrattiana Hook.
Salix bebbiana Sarg.
Salix boothii Dorn
Salix brachycarpa Nutt.
Salix candida Fluegge
Salix commutata Bebb.
Salix discolor Muhl.
Salix drummondiana Barratt
Salix farrae Ball
Salix glauca L.
Salix lanata L. ssp. *calcicola* (Fern. & Wieg.)Hult.
Salix lasiandra Benth.
Salix lucida Muhl. ssp. *caudata* (Nutt.)Argus, B
Salix maccalliana Rowlee, B
Salix mackenzieana (Hook.)Barratt, J
Salix melanopsis Nutt.
Salix monticola Bebb. = *S. pseudomonticola* Ball.
Salix myrtillifolia Anderss.
Salix nivalis Hook. = *S. reticulata* L. var. *nivalis* (Hook.)And.
Salix novae-angliae Anderss., B
Salix pedicellaris Pursh, B
Salix planifolia Pursh
Salix prolixa Anderss., J
Salix pseudocordata (Anderss.)Rydb., J
Salix pyrifolia Anderss.
Salix reticulata L. ssp. *reticulata*, J
Salix scouleriana Barratt
Salix serissima (Bailey)Fern., J
Salix sitchensis Sans., J
Salix stolonifera Cov., J
Salix vestita Pursh

SANTALACEAE
Comandra pallida A.DC.
Geocaulon lividum (Richards.)Fern

SAXIFRAGACEAE

Chrysosplenium iowense Rydb., J
Heuchera cylindrica Dougl.
Heuchera glabra Willd., J
Leptarrhena pyrolifolia (D.Don)R.Br.
Lithophragma glabrum Nutt., B
Lithophragma parviflora (Hook.)Nutt., B
Mitella breweri A.Gray, B
Mitella nuda L.
Mitella pentandra Hook.
Mitella trifida Graham
Parnassia fimbriata Konig.
Parnassia kotzebuei Cham. & Schl.
Parnassia montanensis Fern. & Rydb.
Parnassia palustris L., B
Parnassia parviflora DC.
Ribes glandulosum Grauer, J
Ribes hudsonianum Richards.
Ribes lacustre (Pers.)Poir.
Ribes laxiflorum Pursh
Ribes oxyacanthoides L.
Ribes setosum Lindl., B
Ribes triste Pall., J
Saxifraga adscendens L.
Saxifraga aizoides L.
Saxifraga arguta D.Don., J
Saxifraga bronchialis L.
Saxifraga caespitosa L.
Saxifraga cernua L.
Saxifraga debilis Engelm. = *S. rivularis* L.
Saxifraga ferruginea Graham
Saxifraga flagellaris Willd.
Saxifraga lyallii Engler.
Saxifraga nivalis L.
Saxifraga occidentalis S.Wats.
Saxifraga oppositifolia L.
Saxifraga punctata L. = *S. aestivalis* Fisch & Mey., J
Saxifraga rhomboidea Greene
Saxifraga tricuspidata Rottb., J
Telesonix heucheriformis Rydb. = *T. jamesii* (Torr.)Raf., J
Tiarella unifoliata Hook.

SCROPHULARIACEAE

Castilleja hispida Benth., B
Castilleja miniata Lindl.
Castilleja occidentalis Torr.
Castilleja raupii Pennell
Castilleja rhexifolia Rydb., B
Castilleja septentrionalis Lindl., B
Castilleja sulphurea Rydb., B
Collinsia parviflora Dougl., B
Euphrasia disjuncta Fern. & Wieg., J
Linaria dalmatica (L.)Mill., J
Linaria vulgaris Hill., B
Mimulus guttatus DC., B
Mimulus lewisii Pursh, J
Orthocarpus luteus Nutt., B
Pedicularis arctica R.Br. = *P. langsdorfii* Fisch. ssp. *arctica* (R.Br.)Pennell
Pedicularis bracteosa Benth.
Pedicularis capitata Adams
Pedicularis contorta Benth., B
Pedicularis flammea L.
Pedicularis groenlandica Retz.
Pedicularis labradorica Wirsing, J
Pedicularis lanata Cham. & Schlect., J
Pedicularis racemosa Dougl.
Penstemon confertus Dougl., B
Penstemon ellipticus Coult. & Fisher, B
Penstemon fruticosus (Pursh)Greene var. *scouleri* (Lindl.)Cronq.
Penstemon montanus Greene var. *idahoensis* (Keck)Cronq., B
Penstemon procerus Dougl.
Rhinanthus crista-galli L.
Veronica alpina L. var. *unalaschensis* Coult. & Schult.
Veronica americana (Raf.)Schw., B
Veronica salina Schur., B
Veronica serpyllifolia L., B

UMBELLIFERAE

Carum carvi L.
Heracleum lanatum Michx.
Lomatium columbianum Math. & Const., B
Lomatium dissectum (Nutt.)Math. & Const. var. *multifidum* (Nutt.)Math. & Const., B
Lomatium simplex (Nutt.)Macbr., B
Lomatium triternatum (Pursh) Coult. & Rose, B
Osmorhiza chilensis Hook. & Arn.
Osmorhiza depauperata Philippi
Osmorhiza purpurea (Coult. & Rose)Suksd., J
Pastinaca sativa L., B
Zizia aptera (A.Gray)Fern.

URTICACEAE

Urtica gracilis Ait., J
Urtica lyalli S.Wats.
Urtica urens L.

VALERIANACEAE

Valeriana septentrionalis Rydb.
Valeriana sitchensis Bong.

VIOLACEAE

Viola adunca J.E.Smith
Viola glabella Nutt.
Viola langsdorfii (Regel)Fisch., J
Viola nephrophila Greene
Viola orbiculata Geyer
Viola palustris L.
Viola renifolia A.Gray
Viola rugulosa Greene
Viola selkirkii Pursh.

LILIATAE

ALISMATACEAE

Sagittaria latifolia Willd., B

CYPERACEAE

Carex aenea Fern., B
Carex albo-nigra Mack.
Carex angustior Mack., B
Carex aquatilis Wahlenb.
Carex athabascensis F.J.Hermann, J
Carex atrosquama Mack. = *C. atrata* L.
Carex aurea Nutt.
Carex bebbii Olney, B
Carex bigelowii Torr., B
Carex bipartita Allioni

Carex brunnescens (Pers.)Poir., J
Carex buxbaumii Wahlenb.
Carex canescens L., J
Carex capillaris L. var. *elongata* Olney
Carex capitata L., B
Carex circinata C.A.Mey, J
Carex concinna R.Br.
Carex concinnoides Mack.
Carex crawei Dewey
Carex crawfordii Fern., J
Carex deflexa Mack., B
Carex diandra Schrank, B
Carex disperma Dewey
Carex eburnea Boott
Carex eleocharis Bailey
Carex elusinoides Turcz., J
Carex epapillosa Mack., J
Carex eurystachya F.J.Hermann, B
Carex festivella Mack., B
Carex filifolia Nutt.
Carex flava L.
Carex foenea Willd.
Carex franklinii Boott
Carex garberi Fern. var. *bifaria* Fern.
Carex glacialis Mack., B
Carex gynocrates Wormsk.
Carex haydeniana Olney
Carex heliophila Mack., J
Carex hoodii Boott
Carex illota Bailey, B
Carex incurviformis Mack., B
Carex interior Bailey
Carex lasiocarpa Ehrh., J
Carex lenticularis Michx., J
Carex leptalea Wahlenb.
Carex limnophila F.J.Hermann
Carex limosa L.
Carex livida (Wahlenb.)Willd., B
Carex loliacea L., J
Carex macloviana D'Urv., B
Carex macrochaeta C.A.Mey, J
Carex maritima Mann., B
Carex media R.Br.
Carex mertensii Prescott, J
Carex microglochin Wahlenb.
Carex microptera Mack.
Carex misandra R.Br., J
Carex nardina E.Fries
Carex nigricans C.A.Meyer
Carex obtusata Lilj.
Carex petasata Dewey, B
Carex petricosa Dewey, J
Carex phaeocephala Piper
Carex physocarpa Presl.
Carex platylepis Mack., J
Carex podocarpa R.Br., J
Carex praegracilis W.Boott, J
Carex praticola Rydb.
Carex pyrenaica Wahlenb.
Carex raymondii Calder, B
Carex raynoldsii Dewey, J
Carex richardsonii R.Br.
Carex rossii Boott
Carex rostrata Stokes
Carex rupestris Allioni = *C. drummondiana* Dewey
Carex scirpiformis Mack., B
Carex scirpoidea Michx.
Carex scoparia Schk., J
Carex spectabilis Dewey = *C. tolmiei* Boott
Carex supina Willd. ssp. *spaniocarpa* (Steud.)Hult., B
Carex umbellata Schk.
Carex vaginata Tausch
Carex vesicaria L., B
Carex viridula Michx., J
Carex xerantica Bailey
Eleocharis acicularis (L.) Roem. & Schult., B
Eleocharis palustris (L.) Roem. & Schult., B
Eriophorum angustifolium Honckeny
Eriophorum brachyantherum Trautv.
Eriophorum callitrix Cham., B
Eriophorum scheuchzeri Hoppe
Eriophorum viridi-carinatum (Engelm.)Fern.
Kobresia myosuroides (Vill.) Fiori & Paol. = *K. bellardii* (All.)Degl.
Kobresia simpliciuscula (Wahlenb.)Mack.
Scirpus acutus Muhl.
Scirpus caespitosus L. var. *callosus* Bigel.
Scirpus hudsonianus (Michx.)Fern., J
Scirpus pumilis Vahl ssp. *rollandii* (Fern.)Raymond
Scirpus validus Vahl, J

GRAMINEAE

Agroelymus xmossii Lepage, B
Agropyron cristatum (L.)Gaertn., J
Agropyron dasystachyum (Hook.)Scribn.
Agropyron inerme (Scribn. & Smith)Rydb., J
Agropyron latiglume (Scribn. & Smith)Rydb.
Agropyron repens (L.)Beauv.
Agropyron riparium Scribn. & Smith, B
Agropyron smithii Rydb. var. *molle* (Scribn. & Smith)Jones
Agropyron spicatum (Pursh)Scribn. & Smith, B
Agropyron subsecundum (Link)Hitchc.
Agropyron trachycaulum (Link)Malte
Agropyron violaceum (Hornem.)Lange ssp. *andinum* (Scribn. & Smith)Melderis, B
Agrostis alba L., B
Agrostis borealis Hartm.
Agrostis exarata Trin., B
Agrostis humilis Vasey
Agrostis palustris Huds.
Agrostis scabra Willd.
Agrostis stolonifera L., B
Agrostis thurberiana Hitchc.
Agrostis variabilis Rydb.
Alopecurus aequalis Sobol., B
Beckmannia syzigachne (Steud.)Fern., B
Bromus anomalus Rupr., J
Bromus ciliatus L.
Bromus marginatus Nees, B
Bromus pumpellianus Scribn.
Bromus purgans L., B
Bromus tectorum L., B
Calamagrostis canadensis (Michx.)Beauv.
Calamagrostis inexpansa A.Gray
Calamagrostis montanensis Scribn., B
Calamagrostis neglecta (Ehrh.)Gaertn.,Mey. & Scherb.
Calamagrostis purpurascens R.Br.
Calamagrostis rubescens Buckl., B

Cinna latifolia (Trev.)Griseb., J
Danthonia intermedia Vasey
Deschampsia atropurpurea (Wahlenb.)Scheele
Deschampsia caespitosa (L.)Beauv.
Elymus aristatus Merr., B
Elymus canadensis L.
Elymus glaucus Buckl.
Elymus hirtiflorus Hitchc., B
Elymus innovatus Beal
Festuca baffinensis Polunin
Festuca brachyphylla Schultes = *F. ovina* L. var. *brevifolia* (R.Br.)Wats.
Festuca idahoensis Elmer, B
Festuca ovina L.
Festuca pratensis Huds., B
Festuca rubra L.
Festuca saximontana Rydb.
Festuca scabrella Torr.
Festuca subulata Trin., B
Festuca viridula Vasey, J
Glyceria borealis (Nash)Batchelder
Glyceria elata (Nash)Hitchc., B
Glyceria grandis S.Wats. *ex* A.Gray, B
Glyceria pulchella (Nash)K.Schum., B
Glyceria striata (Lam.)Hitchc.
Helictotrichon hookeri (Scribn.)Henr., B
Hierochloe alpina (Sw.)Roem. & Schult., J
Hierochloe odorata (L.)Beauv.
Hordeum jubatum L.
Koeleria cristata (L.)Pers.
Melica spectabilis Scribn., B
Muhlenbergia glomerata (Willd.)Trin.
Muhlenbergia richardsonis (Trin.)Rydb., B
Oryzopsis asperifolia Michx.
Oryzopsis pungens (Torr.)Hitchc.
Panicum occidentale Scribn., B
Phalaris arundinacea L.
Phleum alpinum L.
Phleum pratense L.
Poa alpina L.
Poa annua L., B
Poa arctica R.Br. = *P. grayana* Vasey
Poa canbyi (Scribn.)Piper, B
Poa cusickii Vasey var. *cusuckii*
Poa cusickii Vasey var. *purpurascens* (Vasey)C.L.Hitchc., J
Poa epilis Scribn. = *P. cusickii* var. *epilis* (Scribn.)Hitchc., B
Poa fendleriana (Steud.)Vasey, J
Poa glauca Vahl (s.l.)
Poa glaucifolia Scribn. & Will., B
Poa incurva Scribn. & Will., B
Poa interior Rydb.
Poa juncifolia Scribn., B
Poa lanata Scribn. & Merr., B
Poa leptocoma Trin. var. *leptocoma*, B
Poa lettermanii Vasey, B
Poa longipila Nash, J
Poa nemoralis L., B
Poa nervosa (Hook.)Vasey
Poa palustris L., B
Poa pattersonii Vasey
Poa paucispicula Scribn. & Merr., B
Poa pratensis L.
Poa rupicola Nash
Poa stenantha Trin., B
Puccinellia distans (L.)Parl., B
Puccinellia nuttalliana (Schult.)Hitchc., B
Schizachne purpurascens (Torr.)Swallen
Secale cereale L., J
Sphenopholis intermedia (Rydb.)Rydb., B
Stipa columbiana Macoun
Stipa comata Trin. & Rupr., J
Stipa richardsonii Link
Trisetum montanum Vasey, B
Trisetum spicatum (L.)Richt.

IRIDACEAE
Sisyrinchium montanum Greene
Sisyrinchium sarmentosum Suksd.

JUNCAGINACEAE
Triglochin maritima L.
Triglochin palustris L.

JUNCACEAE
Juncus albescens (Lange)Fern. = *J. triglumus* L.
Juncus alpinus L.
Juncus balticus Willd.
Juncus biglumis L., B
Juncus castaneus J.E.Smith
Juncus drummondii E.Meyer
Juncus ensifolius Wikstr.
Juncus filiformis L., J
Juncus longistylis Torr., B
Juncus mertensianus Bong.
Juncus nodosus L.
Juncus parryi Engelm., B
Juncus saximontanus A.Nels., B
Juncus stygius L. ssp. *americanus* (Buch.)Hult., B
Juncus tenuis Willd., J
Juncus tracyi Rydb., B
Luzula arcuata (Wahlenb.)Wahlenb.
Luzula confusa Lindebl.
Luzula glabrata (Hoppe)Desv. = *L. hitchcockii* Hamet-Ahti, B
Luzula multiflora (Retz.)Lej., B
Luzula parviflora (Ehrh.)Desv.
Luzula spicata (L.)DC.
Luzula wahlenbergii Rupr.

LEMNACEAE
Lemna minor L., B

LILIACEAE
Allium cernuum Roth
Allium schoenoprasum L. var. *sibiricum* (L.)Hartm.
Clintonia uniflora (Schult.)Kunth, J
Disporum trachycarpum (S.Wats.)Benth. & Hook.
Erythronium grandiflorum Pursh
Lilium philadelphicum L. var. *andinum* (Nutt.)Ker
Maianthemum canadense Desf. var. *interius* Fern., J
Smilacina racemosa (L.)Desf. var. *amplexicaulis* (Nutt.)S.Wats.
Smilacina stellata (L.)Desf.
Smilacina trifolia (L.)Desf., J
Stenanthium occidentale A.Gray, B
Streptopus amplexifolius (L.)DC., J
Tofieldia coccinea Rich., J
Tofieldia glutinosa (Michx.)Pers.

Tofieldia pusilla (Michx.)Pers.
Veratrum eschscholtzii A.Gray = *V. viride* Ait.
Zygadenus elegans Pursh
Zygadenus gramineus Rydb., B

ORCHIDACEAE
Calypso bulbosa (L.)Oakes
Corallorhiza trifida Châtelain
Cypripedium calceolus L. var. *pubescens* (Willd.)Correll
Cypripedium montanum Dougl.
Cypripedium passerinum Richards.
Goodyera oblongifolia Raf.
Goodyera repens (L.)R.Br.
Habenaria dilatata (Pursh)Hook.
Habenaria hyperborea (L.)R.Br.
Habenaria obtusata (Pursh)Richards.
Habenaria orbiculata (Pursh)Torr., J
Habenaria saccata Greene
Habenaria unalascensis (Spreng.)S.Wats., J
Habenaria viridis (L.)R.Br. var. *bracteata* (Muhl.)A.Gray
Listera borealis Morong
Listera caurina Piper
Listera convallarioides (Sw.)Torr., J
Listera cordata (L.)R.Br.
Orchis rotundifolia Banks
Spiranthes romanzoffiana Cham.

POTAMOGETONACEAE
Potamogeton filiformis Pers., B
Potamogeton natans L., B
Potamogeton pusillus L., J
Potamogeton richardsonii (Benn.)Rydb.
Potamogeton vaginatus Turcz., B

SPARGANIACEAE
Sparganium angustifolium Michx., B
Sparganium hyperboreum Laest, J
Sparganium minimum (Hartm.)E.Fries

TYPHACEAE
Typha latifolia L.

MOSSES

Amblyodon dealbatus (Hedw.)B.S.G., B
Amblystegium serpens (Hedw.)B.S.G.
Amblystegium varium (Hedw.)Lindb.
Andreaea rupestris Hedw., J
Aulacomnium palustre (Hedw.)Schwaegr.
Aulacomnium turgidum (Wahlenb.)Schwaegr., J
Barbula acuta (Brid.)Brid.
Barbula andreaeoides Kindb., J
Barbula convoluta Hedw.
Barbula icmadophila Schimp. *ex* C.Muell.
Barbula nigrescens Mitt., B
Barbula reflexa (Brid.)Brid., J
Bartramia ithyphylla Brid.
Blindia acuta (Hedw.)B.S.G., B
Brachythecium albicans (Hedw.)B.S.G.
Brachythecium collinum (Schleich. *ex* C.Muell)B.S.G.
Brachythecium curtum (Lindb.)Limpr.
Brachythecium groenlandicum (C.Jens.)Schljak.
Brachythecium leibergii Grout, B
Brachythecium nelsonii Grout
Brachythecium rivulare B.S.G.
Brachythecium reflexum (Starke *ex* Web. & Mohr)B.S.G., B
Brachythecium salebrosum (Web. & Mohr)B.S.G.
Brachythecium turgidum (C.J.Hartm.)Kindb.
Brachythecium velutinum (Hedw.)B.S.G.
Bryoerythrophyllum recurvirostrum (Hedw.)Chen
Bryum algovicum Sendtn. *ex* C.Muell.
Bryum argenteum Hedw.
Bryum caespiticium Hedw.
Bryum capillare Hedw., J
Bryum flaccidum Brid., B
Bryum lisae DeNot. var. *cuspidatum* (B.S.G.)Marg., B
Bryum pallescens Schleich. *ex* Schwaegr., J
Bryum pseudotriquetrum (Hedw.)Gaertn., Meyer & Schreb.
Bryum stenotrichum C.Muell., B
Bryum stirtonii Schimp.
Bryum weigelii Spreng.
Buxbaumia aphylla Hedw., J
Calliergon cordifolium (Hedw.)Kindb., J
Calliergon giganteum (Schimp.)Kindb.
Calliergon richardsonii (Mitt.)Kindb. *ex* Warnst.
Calliergon sarmentosum (Wahlenb.)Kindb., J
Calliergon stramineum (Brid.)Kindb., J
Calliergon trifarium (Web. & Mohr)Kindb.
Campylium chrysophyllum (Brid.)J.Lange
Campylium halleri (Hedw.)Lindb.
Campylium hispidulum (Brid.)Mitt., J
Campylium polygamum (B.S.G.)C.Jens.
Campylium radicale (P. Beauv.)Grout
Campylium stellatum (Hedw.)C.Jens.
Catoscopium nigritum (Hedw.)Brid.
Ceratodon purpureus (Hedw.)Brid.
Cinclidium stygium Sw.
Climacium dendroides Web. & Mohr
Conostomum tetragonum (Hedw.)Lindb., J
Cratoneuron commutatum (Hedw.)Roth
Cratoneuron filicinum (Hedw.)Spruce
Cynodontium strumiferum (Hedw.)Lindb., J
Desmatodon latifolius (Hedw.)Brid.
Desmatodon obtusifolius (Schwaegr.)Schimp., J
Desmatodon systylius Schimp.
Dichodontium pellucidum (Hedw.)Schimp., B
Dicranella grevilleana (Brid.)Schimp., B
Dicranoweisia crispula (Hedw.)Lindb. *ex* Milde
Dicranum acutifolium (Lindb. & Arnell)C.Jens. *ex* Weinm.
Dicranum angustum Kindb., B
Dicranum brevifolium Kindb.
Dicranum brevifolium Kindb. var. *bistratosum* Peters.
Dicranum elongatum Schleich. & Schwaegr.
Dicranum flagellare Hedw.
Dicranum fragilifolium Lindb.
Dicranum fuscescens Turn.
Dicranum muehlenbeckii B.S.G.
Dicranum polysetum Sw.
Dicranum scoparium Hedw.
Dicranum spadiceum Zett., J

Dicranum undulatum Brid.
Didymodon johansenii (Williams)Crum, J
Distichium capillaceum (Hedw.)B.S.G.
Distichium inclinatum (Hedw.)B.S.G.
Ditrichum flexicaule (Schwaegr.)Hampe
Drepanocladus aduncus (Hedw.)Warnst.
Drepanocladus exannulatus (B.S.G.)Warnst.
Drepanocladus revolvens (Sw.)Warnst.
Drepanocladus sendtneri (Schimp.)Warnst., J
Drepanocladus uncinatus (Hedw.)Warnst.
Drepanocladus vernicosus (Lindb. *ex* C.Hartm.)Warnst., J
Encalypta affinis R. Hedw.
Encalypta alpina Sm.
Encalypta brevipes Schljak., B
Encalypta brevicolla (B.S.G.)Bruch *ex* Angstr.
Encalypta ciliata Hedw.
Encalypta mutica Hagen, B
Encalypta procera Bruch
Encalypta rhaptocarpa Schwaegr.
Encalypta spathulata C.Muell., B
Entodon concinnus (DeNot.)Par., J
Eurhynchium pulchellum (Hedw.)Jenn.
Fissidens adiantoides Hedw.
Fissidens bryoides Hedw., J
Fissidens osmundoides Hedw.
Fontinalis hypnoides C.J.Hartm. var. *duriaei* (Schimp.)Husn., J
Funaria hygrometrica Hedw.
Grimmia affinis Hoppe & Hornsch. *ex* Hornsch.
Grimmia alpicola Hedw.
Grimmia anodon B.S.G.
Grimmia apocarpa Hedw.
Grimmia calyptrata Hook. *ex* Drumm., J
Grimmia rauii Aust., J
Grimmia tenerrima Ren. & Card., J
Grimmia torquata Hornsch. *ex* Grev., J
Gymnostomum recurvirostrum Hedw.
Hedwigia ciliata (Hedw.)P. Beauv., J
Helodium blandowii (Web. & Mohr)Warnst., J
Heterocladium dimorphum (Brid.)B.S.G., J
Homalothecium aeneum (Mitt.)Lawt., J
Hygrohypnum bestii (Ren. & Bryhn *ex* Ren.)Holz. *ex* Broth., J
Hygrohypnum luridum (Hedw.)Jenn., J
Hylocomium pyrenaicum (Spruce)Lindb., J
Hylocomium splendens (Hedw.)B.S.G.
Hypnum bambergeri Schimp.
Hypnum cupressiforme Hedw.
Hypnum lindbergii Mitt.
Hypnum pratense Koch *ex* Brid., J
Hypnum procerrimum Mol., J
Hypnum recurvatum (Lindb. & Arn.)Kindb.
Hypnum revolutum (Mitt.)Lindb.
Hypnum vaucheri Lesq.
Isopterygium pulchellum (Hedw.)Jaeg. & Sauerb.
Kiaeria starkei (Web. & Mohr)Hag., J
Leptobryum pyriforme (Hedw.)Wils.
Leskeella nervosa (Brid.)Loeske
Meesia triquetra (Richt.)Angstr., B
Meesia uliginosa Hedw.
Mnium arizonicum Amann
Mnium blyttii B.S.G.
Mnium cuspidatum Hedw.
Mnium drummondii (Bruch & Schimp.), B
Mnium hymenophylloides Hueb.
Mnium hymenophyllum B.S.G., J
Mnium lycopodioides Schwaegr.
Mnium medium B.S.G.
Mnium nudum Williams *ex* Britt. & Williams, J
Mnium pseudopunctatum Bruch & Schimp.
Mnium rugicum Laur.
Mnium spinulosum B.S.G.
Mnium thompsonii Schimp.
Myurella julacea (Schwaerg.)B.S.G.
Myurella tenerrima (Brid.)Lindb.
Oncophorus virens (Hedw.)Brid.
Oncophorus wahlenbergii Brid., J
Orthothecium chryseum (Schwaegr. *ex* Schultes)B.S.G.
Orthothecium intricatum (C.J.Hartm.)B.S.G.
Orthothecium strictum Lor., B
Orthotrichum jamesianum Sull. *ex* James, B
Orthotrichum laevigatum Zett.
Orthotrichum obtusifolium Brid.
Orthotrichum pallens Bruch *ex* Brid.
Orthotrichum pumilum Sw., B
Orthotrichum rupestre Schleich. *ex* Schwaegr., B
Orthotrichum speciosum Nees *ex* Sturm var. *speciosum*
Orthotrichum speciosum Nees *ex* Sturm var. *elegans* (Schwaegr. *ex* Hook. &Grev.)Warnst.
Orthotricum affine Brid., J
Orthotricum alpestre Hornsch. *ex* B.S.G.
Orthotricum anomalum Hedw.
Paludella squarrosa (Hedw.)Brid.
Paraleucobryum enerve (Thed. *ex* C.J.Hartm.)Loeske
Paraleucobryum longifolium (Hedw.)Loeske
Philontis fontana (Hedw.)Brid. var. *fontana*, B
Philontis fontana (Hedw.)Brid. var. *pumila* (Turn.)Brid.
Plagiobryum demissum (Hook.)Lindb.
Plagiobryum zierii (Hedw.)Lindb., J
Plagiopus oederiana (Sw.)Limpr.
Plagiothecium denticulatum (Hedw.)B.S.G.
Plagiothecium laetum B.S.G.
Plagiothecium undulatum (Hedw.)B.S.G., J
Platydictya jungermannioides (Brid.)Crum
Pleurozium schreberi (Brid.)Mitt.
Pogonatum alpinum (Hedw.)Roehl.
Pogonatum dentatum (Brid.)Brid., J
Pogonatum urnigerum (Hedw.)P.-Beauv., J
Pohlia cruda (Hedw.)Lindb.
Pohlia drummondii (C.Muell.)Andr., B
Pohlia elongata Hedw.
Pohlia nutans (Hedw.)Lindb.
Pohlia proligera (Kindb. *ex* Limpr.)Lindb. *ex* Arnell, B
Pohlia wahlenbergii (Web. & Mohr)Andr.
Polytrichum commune Hedw.
Polytrichum juniperinum Hedw.
Polytrichum longisetum Brid., J
Polytrichum piliferum Hedw.
Polytrichum sexangulare Brid., J
Polytrichum strictum Brid.
Pseudoleskea radicosa (Mitt.)Macoun & Kindb. var. *compacta* Best
Pseudoleskeella tectorum (Funck *ex*

Brid.)Kindb. *ex* Broth. var. *tectorum*
Pseudoleskeella catenulata (Brid. *ex* Schrad.)Kindb., B
Pterigynandrum filiforme Hedw., J
Ptilium crista-castrensis (Hedw.)DeNot.
Pylaisiella polyantha (Hedw.)Grout
Rhacomitrium canescens (Hedw.)Brid., J
Rhacomitrium fasciculare (Hedw.)Brid., J
Rhacomitrium heterostichum (Hedw.)Brid. var. *sudeticum* (Funck)Dix. *ex* Bauer, J
Rhacomitrium heterostichum (Hedw.)Brid. var. *heterostichum*
Rhacomitrium lanuginosum (Hedw.)Brid., J
Rhizomnium gracile Koponen
Rhizomnium magnifolium (Horik.)Koponen
Rhytidiadelphus squarrosus (Hedw.)Warnst., J
Rhytidiadelphus triquetrus (Hedw.)Warnst.
Rhytidiopsis robusta (Hedw.)Broth.
Rhytidium rugosum (Hedw.)Kindb.
Roellia roellii (Broth. *ex* Roell)Andr. *ex* Crum
Saelania glaucescens (Hedw.)Bomanss. & Broth.
Scorpidium scorpioides (Hedw.)Limpr.
Scorpidium turgescens (T.Jens.)Loeske
Sphagnum capillaceum (Weiss)Schrank
Sphagnum compactum DC. *ex* Lam. & DC., J
Sphagnum fuscum (Schimp.)Klinggr.
Sphagnum girgensohnii Russ., J
Sphagnum lindbergii Schimp. *ex* Lindb., J
Sphagnum recurvum P. Beauv. var. *tenue* Klinggr., J
Sphagnum russowii Warnst., J
Sphagnum squarrosum Crome, J
Sphagnum teres (Schimp.)Angstr. *ex* C.Hartm., J
Sphagnum warnstorfii Russ.
Splachnum sphaericum Hedw.
Stegonia latifolia (Schwaegr. *ex* Schultes)Vent. *ex* Broth. var. *latifolia*
Stegonia latifolia (Schwaegr. *ex* Schultes)Vent. *ex* Broth. var. *pilifera* (Brid.)Broth
Tayloria serrata (Hedw.)B.S.G., J
Tetraphis pellucida Hedw.
Tetraplodon angustatus (Hedw.)B.S.G.
Tetraplodon mnioides (Hedw.)B.S.G. var. *cavifolius* Schimp., J
Thuidium abietinum (Hedw.)B.S.G.
Thuidium recognitum (Hedw.)Lindb.
Timmia austriaca Hedw.
Timmia megapolitana Hedw.
Tomenthypnum nitens (Hedw.)Loeske
Tortella fragilis (Drumm.)Limpr.
Tortella inclinata (R.Hedw.)Limpr.
Tortella tortuosa (Hedw.)Limpr.
Tortula mucronifolia Schwaegr.
Tortula norvegica (Web.)Wahlenb. *ex* Lindb.
Tortula ruralis (Hedw.)Gaertn., Meyer & Schreb.
Voitia nivalis Hornsch., B

LIVERWORTS

Anastrophyllum helleranum (Nees)Schust., J
Anastrophyllum minutum (Schreb.)Schust., J
Aneura pinguis (L.)Dum., B
Anthelia julacea (L.)Dum., J
Anthelia juratzkana (Limpr.)Trev., J
Arnellia fennica (Gott.)Lindb., J
Asterella ludwigii (Schwaegr.)Underw., J
Athalamia hyalina (Sommert.)Hatt., B
Barbilophozia hatcheri (Evans)Loeske
Barbilophozia lycopodioides (Wallr.)Loeske
Blepharostoma tricophyllum (L.)Dum.
Calypogeja integristipula Steph., J
Calypogeja neesiana (Mass. & Carest.)K.Muell., J
Calypogeja sphagnicola (H.Arnell & J. Perss.)Warnst. & Loeske, J
Calypogeja suecia (H.Arnell & J.Perss.)K.Muell., J
Cephalozia lunulifolia (Dum.)Dum., B
Chandonanthus setiformis (Ehrh.)Lindb., J
Geocalyx graveolens (Schrad.)Nees, J
Gymnomitrion corallioides Nees, J
Gymnomitrion concinnatum (Lightf.)Corda, J
Harpanthus flotovianus (Nees)Nees, J
Jamesoniella autumnalis (DC.)Steph., J
Jungermannia exsertifolia ssp. *cordifolia* (Dum.)Vana var. *cordifolia*, J
Lepidozia reptans (L.)Dum., J
Lophocolea heterophylla (Schrad.)Dum., J
Lophozia excisa (Dicks.)Dum., J
Lophozia floerkii (Web. & Mohr)Schiffn.
Lophozia incisa (Schrad.)Dum. J
Lophozia kunzeana (Hueb.)Evans = *Barbilophozia kunzeana* (Heub.)Gams
Lophozia laxa (Lindb.)Grolle, J
Lophozia quadriloba (Lindb.)Evans
Lophozia rutheana (Limpr.)M.A.Howe., J
Lophozia ventricosa (Dicks.)Dum.
Lophozia wenzelii (Nees)Steph., B
Marchantia polymorpha L.
Marsupella emarginata (Ehrh.)Dum., J
Marsupella sphacelata (Gieseke)Dum., J
Mylia anomala (Hook.)S.Gray
Plagiochila asplenioides (L.)Dum.
Pleuroclada albescens (Hook.)Spruce
Preissia quadrata (Scop.)Nees
Ptilidium ciliare (L.)Hampe, J
Ptilidium pulcherrimum (G.Web.)Hampe
Radula complanata (L.)Dum., J
Scapania cuspiduligera (Nees)K.Muell., J
Scapania paludicola Loeske & K.Muell., J
Scapania paludosa (K.Muell.)K.Muell.
Scapania undulata (L.)Dum., J
Tritomaria exsectiformis (Breidl.)Loeske
Tritomaria heterophylla Schust., B
Tritomaria polita (Nees)Joerg., J
Tritomaria quinquedentata (Huds.)Buch, J
Tritomaria scitula (Tayl.)Joerg.

LICHENS

Acaraspora chlorophana (Wahlenb. *ex* Ach.) Mass.
Acarospora fuscata (Schrad.)Arn.
Acaraspora glaucocarpa (Wahlenb. *ex* Ach.) Koerb., B
Acaraspora smaragdula (Wahlenb. *ex* Ach.) Mass., B
Acarospora oligospora (Nyl.) Arn.
Acarospora smaragdula (Wahlenb. *ex* Ach.)Mass., B

Acarospora strigata (Nyl.)Jatta, B
Acarospora veronensis Mass., B
Alectoria nigricans (Ach.)Nyl.
Alectoria ochroleuca (Hoffm.)Mass.
Alectoria sarmentosa (Ach.)Ach. ssp. *vexillifera* (Nyl.)D.Hawksw.
Arthonia patellulata Nyl., J
Arthopyrenia punctiformis (Perss.)Mass., J
Arthroraphis citrinella (Ach.)Poelt., J
Aspicilia alpina (Somm.)Arn.
Aspicilia caesiocinerea (Nyl. *ex* Malbr.)Arn.
Aspicilia calcarea (L.)Mudd., B
Aspicilia candida (Anzi)Nyl.
Aspicilia cinerea (L.)Koerb.
Aspicilia cinereorufescens (Ach.)Mass.
Aspicilia elevata Lynge, J
Aspicilia nikrapensis (Darb.)Zahlbr., J
Aspicilia perigibbosa Magn., B
Aspicilia rolleana (Hue)Zahlbr., B
Aspicilia supertegens (Arn.)Zahlbr.
Bacidia acclinis (Mass.)Zahlbr., B
Bacidia bagliettoana (Mass. & DeNot.)Jatta
Bacidia obscurata (Somm.)Zahlbr., J
Bacidia sphaeroides (Dicks.)Zahlbr.
Baeomyces rufus (Huds.)Rebent., J
Bryoria abbreviata (Muell.Arg.)Brodo & D.Hawksw., J
Bryoria capillaris (Ach.)Brodo & D.Hawksw.
Bryoria chalybeiformis (L.)Brodo & D.Hawksw. = *Alectoria chalybeiformis* (L.)S.Gray
Bryoria fremontii (Tuck.)Brodo & D.Hawksw. = *Alectoria fremontii* Tuck.
Bryoria furcellata (Fr.)Brodo & D.Hawksw., J
Bryoria fuscescens (Gyeln.)Brodo & D.Hawksw. = *Alectoria fuscescens* (Gyeln.)
Bryoria glabra (Mot.)Brodo & D.Hawksw. = *Alectoria glabra* Mot.
Bryoria implexa (Hoffm.)Brodo & D.Hawksw. = *Alectoria implexa* (Hoffm.)Nyl., J
Bryoria lanestris (Ach.)Brodo & D.Hawksw.
Bryoria oregana (Tuck.)Brodo & D.Hawksw., J
Bryoria pseudofuscescens (Gyeln)Brodo & D.Hawksw. = *Alectoria pseudofuscescens* Gyeln., J
Bryoria simplicior (Vain.)Brodo & D.Hawksw.
Bryoria trichodes (Michx.)Brodo & D.Hawksw. = *Alectoria americana* Mot.
Buellia disciformis (Fr.)Mudd
Buellia epigaea (Hoffm.)Tuck.
Buellia papillata (Somm.)Tuck.
Buellia punctata (Hoffm.)Mass.
Buellia spuria (Schaer.)Anzi, B
Buellia triphragmioides Anzi
Calicium abietinum Pers.
Calicium salicinum Pers., J
Calicium viride Pers., J
Caloplaca atroalba (Tuck.)Zahlbr., B
Caloplaca aurantiaca (Lightf.)Th.Fr., J
Caloplaca cerina (Ehrh.)Th.Fr.
Caloplaca citrina (Hoffm.)Th.Fr.
Caloplaca cladodes (Tuck.)Zahlbr., J
Caloplaca epithallina Lynge
Caloplaca ferruginea (Huds.)Th.Fr., B
Caloplaca flavovirescens (Wulf.)DallaTorre & Sarnth., B
Caloplaca holocarpa (Hoffm.)Wade
Caloplaca jungermanniae (Vahl)Th.Fr.
Caloplaca lactea (Mass.)Zahlbr., B
Caloplaca murorum (Hoffm.)Th.Fr.
Caloplaca sinapisperma (Lam.)Mah. & Gill.
Caloplaca stillicidiorum (Vahl)Lynge
Caloplaca tetraspora (Nyl.)Oliv.
Caloplaca vitellinula (Nyl.)Oliv.
Candelaria concolor (Dicks.)B.Stein., B
Candelariella aurella (Hoffm.)Zahlbr.
Candelariella canadensis Magn., J
Candelariella terrigena Raes., J
Candelariella vitellina (Ehrh.)Muell.Arg.
Candelariella xanthostigma (Ach.)Lett.
Catillaria chalybeia (Borr.)Mass., J
Catillaria dufourei (Ach.)Vain., B
Catillaria griffithii (Sm.)Malme
Cetraria canadensis (Raes.)Raes.
Cetraria chlorophylla (Willd.)Vain.
Cetraria ciliaris Ach.
Cetraria commixta (Nyl.)Th.Fr.
Cetraria cucullata (Bell.)Ach.
Cetraria ericetorum Opiz
Cetraria halei W.Culb & C.Culb
Cetraria hepatizon (Ach.)Vain.
Cetraria islandica (L.)Ach.
Cetraria laevigata Rass.
Cetraria merrillii DuRietz
Cetraria nivalis (L.)Ach.
Cetraria pinastri (Scop.)S.Gray
Cetraria platyphylla Tuck., J
Cetraria sepincola (Ehrh.)Ach.
Cetraria subalpina Imsh.
Cetraria tilesii Ach.
Cladonia acuminata (Ach.)Norrl.
Cladonia arbuscula (Wallr.)Rabenh.
Cladonia bacillaris (Ach.)Nyl.
Cladonia bacilliformis (Nyl.)DallaTorre & Sarnth., J
Cladonia bellidiflora (Ach.)Schaer., J
Cladonia botrytes (Hag.)Willd.
Cladonia brevis (Sandst.)Sandst., B
Cladonia cariosa (Ach.)Spreng.
Cladonia carneola (Fr.)Fr.
Cladonia cenotea (Ach.)Schaer.
Cladonia chlorophaea (Floerke *ex* Somm.)Spreng.
Cladonia clavulifera Vain., B
Cladonia coccifera (L.)Willd.
Cladonia coniocraea (Floerke)Spreng.
Cladonia cornuta (L.)Hoffm.
Cladonia crispata (Ach.)Flot.
Cladonia cristatella Tuck., J
Cladonia decorticata (Floerke)Spreng.
Cladonia deformis (L.)Hoffm.
Cladonia digitata (L.)Hoffm., J
Cladonia ecmocyna (Ach.)Nyl.
Cladonia fimbriata (L.)Fr.
Cladonia furcata (Huds.)Schrad.
Cladonia glauca Floerke, B
Cladonia gonecha (Ach.)Asah.
Cladonia gracilis (L.)Willd.
Cladonia lepidota Nyl.
Cladonia macilenta Hoffm.
Cladonia macrophylla (Schaer.)Stenham., J
Cladonia mitis Sandst.

Cladonia multiformis Merr.
Cladonia nemoxyna (Ach.)Nyl., B
Cladonia phyllophora Hoffm.
Cladonia pleurota (Floerke)Schaer.
Cladonia pocillum (Ach.)O.Rich.
Cladonia polydactyla (Floerke)Spreng., J
Cladonia pyxidata (L.)Hoffm.
Cladonia rangiferina (L.)Wigg., J
Cladonia scabriuscula (Del. *ex* Duby)Nyl., J
Cladonia squamosa (Scop.)Hoffm.
Cladonia stellaris (Opiz)Pouz. & Vezda, J
Cladonia subcariosa Nyl.
Cladonia subcervicornis (Vain.)DuRietz, B
Cladonia subulata (L.)Wigg.
Cladonia uncialis (L.)Wigg., J
Cladonia verticillata (Hoffm.)Schaer.
Coelocaulon aculeatum (Schreb.)Link
Coelocaulon divergens (Ach.)R.W.Howe, J
Collema polycarpon Hoffm.
Collema subflaccidum Degel
Collema tuniforme (Ach.)Ach.
Collema undulatum Laur. *ex* Flot. var. *granulosum* Degel
Coniocybe furfuracea (L.)Ach., J
Cyphelium inquinans (Sm.)Trev., B
Cyphelium pinicola L.Tibell
Dactylina arctica (Hook.)Nyl.
Dactylina beringica Bird. & Thoms., J
Dactylina ramulosa (Hook.)Tuck.
Dermatocarpon cinereum (Pers.)Th.Fr., J
Dermatocarpon fluviatile (G.Web.)Th.Fr., J
Dermatocarpon hepaticum (Ach.)Th.Fr.
Dermatocarpon lachneum (Ach.)A.L.Sm., J
Dermatocarpon miniatum (L.)Mann, J
Dermatocarpon reticulatum Magn.
Dermatocarpon vagans Imsh., B
Dimelaena oreina (Ach.)Norm.
Diploschistes scruposus (Schreb.)Norm.
Endocarpon tortuosum Herre
Evernia divaricata (L.)Ach.
Evernia mesomorpha Nyl., J
Fulgensia bracteata (Hoffm.)Raes.
Fulgensia fulgens (Sw.)Elenk.
Glyphoiecia scabra (Pers.)Muell.Arg., J
Haematomma lapponicum Raes.
Huilia crustulata (Ach.)Hertel, J
Huilia glaucophaea (Koerb.)Hertel, J
Hulia nigrocruenta (Anzi)Hertel, B
Hypocenomyce scalaris (Ach.)Choisy
Hypogymnia austerodes (Nyl.)Raes.
Hypogymnia bitteri (Lynge)Ahti, J
Hypogymnia duplicata (Sm. *ex* Ach.)Rass.
Hypogymnia enteromorpha (Ach.)Nyl.
Hypogymnia imshaugii Krog
Hypogymnia oroarctica Krog
Hypogymnia physodes (L.)Nyl.
Hypogymnia subobscura (Vain.)Poelt
Hypogymnia tubulosa (Schaer.)Hav.
Icmadophila ericetorum (L.)Zahlbr.
Ionaspis melanocarpa (Kremp.)Arn., J
Ionaspis ochraceella (Nyl.)Magn., J
Lasallia pensylvanica (Hoffm.)Llano, J
Lecanora alphoplaca (Wahl. *ex* Ach.)Ach., J
Lecanora badia (Hoffm.)Ach.
Lecanora castanea (Hepp)Th.Fr., J
Lecanora cenisia Ach.
Lecanora chrysoleuca (Sm.)Ach., B
Lecanora coilocarpa (Ach.)Nyl.
Lecanora crenulata (Dicks.)Nyl., B
Lecanora dispersa (Pers.)Somm., J
Lecanora epibyron (Ach.)Ach.
Lecanora frustulosa (Dicks.)Ach.
Lecanora granatina Somm., B
Lecanora hageni (Ach.)Ach.
Lecanora hypoptoides Nyl.
Lecanora melanophthalma (Ram.)Ram.
Lecanora muralis (Schreb.)Rabenh.
Lecanora polytropa (Ehrh.)Rabenh.
Lecanora rupicola (L.)Zahlbr., B
Lecanora subfusca (L.)Ach.
Lecanora thamnoplaca Tuck.
Lecanora varia (Ehrh.)Ach.
Lecidea assimilata Nyl., J
Lecidea atrobrunnea (Ram.)Schaer., B
Lecidea atromarginata Magn., B
Lecidea auriculata Th.Fr., J
Lecidea berengeriana (Mass.)Nyl.
Lecidea cinnabarina Somm.
Lecidea demissa (Rutstr.)Ach., B
Lecidea fuscescens Somm.
Lecidea granulosa (Ehrh.)Ach.
Lecidea hypocrita Massal.
Lecidea lapicida (Ach.)Ach., J
Lecidea lithophila (Ach.)Ach., J
Lecidea marginata Schaer.
Lecidea pantherina (Hoffm.)Th.Fr., J
Lecidea scotopholis (Tuck.)Herre, B
Lecidea symmicta (Ach.)Ach., J
Lecidea tessellata (Ach.)Floerke
Lecidea tornoensis Nyl., J
Lecidea turgidula Fr.
Lecidea uliginosa (Schrad.)Ach.
Lecidea umbonata (Hepp)Mudd, J
Lecidea vernalis (L.)Ach.
Lecidea vorticosa (Floerke)Koerb., J
Lecidella glomerulosa (DC.)Choisy
Lecidella goniophila (Floerke)Floerke, J
Lecidella stigmatea (Ach.)Hert. & Leuck.
Lecidella wulfenii (Hepp)Koerb.
Lepraria chlorina (Ach.)Ach. ex Sm., B
Lepraria incana (L.)Ach., B
Lepraria membranacea (Dicks.)Vain.
Lepraria neglecta (Nyl.)Lett.
Leptogium burnetiae Dodge var. *hirsutum* (Sierk)M.M.Jorg., J
Leptogium furfuraceum (Harm.)Sierk, J
Leptogium saturninum (Dicks.)Nyl.
Letharia columbiana (Nutt.)Thoms., J
Letharia vulpina (L.)Hue
Lobaria linita (Ach.)Rabenh.
Lobaria oregana (Tuck.)Muell.Arg., J
Lobaria pulmonaria (L.)Hoffm.
Mycoblastus affinis (Schaer.)Schauer, J
Mycoblastus sanguinarius (L.)Th.Fr., J
Nephroma arcticum (L.)Torss.
Nephroma bellum (Spreng.)Tuck.
Nephroma expallidum (Nyl.)Nyl.
Nephroma helveticum Ach., J
Nephroma parile (Ach.)Ach.
Nephroma resupinatum (L.)Ach., J
Ochroechia frigida (Sw.)Lynge
Ochrolechia androgyna (Hoffm.)Arn., B
Ochrolechia arborea (Ljubitz.)Almb., J
Ochrolechia geminipara (Th.Fr.)Vain.
Ochrolechia inaequatula (Nyl.)Zahlbr., J
Ochrolechia sorediosa Howard, B

Ochrolechia upsaliensis (L.)Mass.
Pachyospora verrucosa (Ach.)Mass.
Pannaria microphylla (Sw.)Mass., B
Pannaria pezizoides (G.Web.)Trev.
Parmelia centrifuga (L.)Ach., J
Parmelia chlorochroa Tuck.
Parmelia disjuncta Erichs., J
Parmelia elegantula (Zahlbr.)Szat.
Parmelia exasperata DeNot., B
Parmelia exasperatula Nyl.
Parmelia infumata Nyl.
Parmelia lineola Berry, B
Parmelia omphalodes (L.)Ach., J
Parmelia saxatilis (L.)Ach., J
Parmelia septentrionalis (Lynge)Ahti, J
Parmelia sphaerosporella Muell.Arg., J
Parmelia subelegantula Essl.
Parmelia subolivacea Nyl.
Parmelia substygia Raes, J
Parmelia sulcata Tayl.
Parmelia taractica Kremp., B
Parmelia wyomingica Gyeln, B
Parmeliopsis aleurites (Ach.)Nyl.
Parmeliopsis ambigua (Wulf.)Nyl.
Parmeliopsis hyperopta (Ach.)Ach.
Peltigera aphthosa (L.)Willd.
Peltigera canina (L.)Willd.
Peltigera collina (Ach.)Ach., J
Peltigera horizontalis (Huds.)Baumg.
Peltigera lepidophora (Nyl.)Vain.
Peltigera leucophlebia (Nyl.)Gyeln., B
Peltigera malacea (Ach.)Funck.
Peltigera polydactyla (Neck.)Hoffm.
Peltigera praetextata (Floerke *ex* Somm.)Vain., J
Peltigera rufescens (Weis.)Humb.
Peltigera scabrosa Th.Fr.
Peltigera spuria (Ach.)DC.
Peltigera venosa (L.)Baumg.
Pertusaria dactylina (Ach.)Nyl., J
Pertusaria panyrga (Ach.)Mass., J
Pertusaria trochiscea Norm., J
Physcia adscendens (Th.Fr.)Oliv.
Physcia aipolia (Ehrh.)Hampe
Physcia biziana (Mass.)Zahlbr.
Physcia constipata (Nyl.)Norrl. & Nyl., B
Physcia dubia (Hoffm.)Lett.
Physcia endococcinea (Koerb.)Th.Fr.
Physcia intermedia Vain., B
Physcia leptalea (Ach.)DC., J
Physcia millegrana Degel., J
Physcia orbicularis (Neck.)Poetsch
Physcia setosa (Ach.)Nyl., J
Physcia stellaris (L.)Nyl., J
Physcia subobscura (Nyl.)Nyl., J
Physconia detersa (Nyl.)Poelt
Physconia farrea (Ach.)Poelt, B
Physconia muscigena (Ach.)Poelt
Placynthium nigrum (Huds.)S. Gray, J
Platismatia glauca (L.)W.Culb. & C.Culb.
Polyblastia henscheliana (Koerb.)Loennr., J
Polyblastia hyperborea Th.Fr., J
Polyblastia intergrascens (Nyl.)Vain.
Polyblastia obsoleta Arn., J
Polyblastia sendtneri Kremph., J
Polyblastia theleodes (Somm.)Th.Fr., J
Protoblastenia rupestris (Scop.)J.Stein.
Pseudephebe minuscula (Nyl. *ex* Arnold)Brodo & D.Hawksw.
Pseudephebe pubescens (L.)Choisy
Psora decipiens (Hedw.)Hoffm.
Psora rubiformis (Ach.)Hook.
Psoroma hypnorum (Vahl)S.Gray
Pyrenula leucoplaca (Wallr.)Koerb., J
Ramalina farinacea (L.)Ach., B
Ramalina fastigiata (Pers.)Ach.
Ramalina pollinaria (Westr.)Ach.
Ramalina roesleri (Hochst.)Nyl., J
Ramalina sinensis Jatta, J
Ramalina thrausta (Ach.)Nyl.
Rhizocarpon chioneum (Norm.)Th.Fr.
Rhizocarpon disporum (Naeg. *ex* Hepp)Muell.Arg.
Rhizocarpon geographicum (L.)DC.
Rhizocarpon grande (Floerke *ex* Flot.)Arn., B
Rinodina annulata Magn., B
Rinodina archaea (Ach.)Arn.
Rinodina bischoffii (Hepp)Mass., J
Rinodina nimbosa (Fr.)Th.Fr. var. *nuda* Lynge
Rinodina nimbosa (Fr.)Th.Fr. var. *pruinosa* (Havas)Lynge, J
Rinodina occidentalis Lynge
Rinodina polyspora Th.Fr., J
Rinodina roscida (Somm.)Arn.
Rinodina turfacea (Wahl.)Koerb.
Sarcogyne novomexicana Magn., J
Sarcogyne privigna (Ach.)Mass., J
Sarcogyne simplex (Dav.)Nyl., B
Solorina bispora Nyl.
Solorina crocea (L.)Ach.
Solorina octospora Arn., J
Solorina saccata (L.)Ach.
Solorina spongiosa (Sm.)Anzi
Solorinella asteriscus Anzi, J
Sphaerophorus globosus (Huds.)Vain., J
Sporastatia testudinea (Ach.)Mass.
Squamarina lentigera (G.Web.)Poelt, J
Staurothele catalepta (Ach.)Blomb. & Forss., B
Staurothele clopima (Wahl. *ex* Ach.)Th.Fr.
Staurothele perradiata Lynge, B
Stereocaulon alpinum Laur.
Stereocaulon condensatum Hoffm., B
Stereocaulon paschale (L.)Hoffm., J
Stereocaulon pileatum Ach.
Stereocaulon tomentosum Fr.
Synalissa symphorea (Ach.)Nyl., J
Thamnolia subuliformis (Ehrh.)W.Culb.
Thelidium decipiens (Nyl.)Kremp., B
Thelidium pyrenophorum (Ach.)Mudd
Toninia caeruleonigricans (Lightf.)Th.Fr
Toninia candida (Web.)Th.Fr.
Toninia lobulata (Somm.)Lynge, B
Tremolecia atrata (Ach.)Hertel, J
Tremolecia jurana (Schaer.)Hertel
Umbilicaria arctica (Ach.)Nyl., J
Umbilicaria cylindrica (L.)Del., J
Umbilicaria deusta ((L.)Baumg.
Umbilicaria hyperborea (Ach.)Ach.
Umbilicaria polyphylla (L.)Baumg., J
Umbilicaria proboscidea (L.)Schrad.
Umbilicaria torrefacta (Lightf.)Schrad., J
Umbilicaria vellea (L.)Ach., B
Umbilicaria virginis Schaer.
Usnea alpina Mot.

Usnea cavernosa Tuck., J
Usnea compacta Mot., J
Usnea glabrescens (Nyl.*ex* Vain.)Vain.
Usnea hirta (L.)Wigg., J
Usnea sorediifera (Arn.)Lynge
Usnea subfloridana Stirt.
Varicellaria kemensis Raes.
Varicellaria rhodocarpa (Koerb.)Th.Fr., J
Verrucaria calkinsiana Serv.
Verrucaria fuscella (Turn.)Ach., J
Verrucaria muralis Ach., J
Verrucaria nigrescens Pers., B
Verrucaria virens Nyl.
Xanthoria candelaria (L.)Th.Fr.
Xanthoria elegans (Link)Th.Fr.
Xanthoria fallax (Hepp)Arn.
Xanthoria sorediata (Vain.)Poelt, B
Xylographa abietina (Pers.)Zahlbr.
Xylographa vitiligo (Ach.)Laund., J

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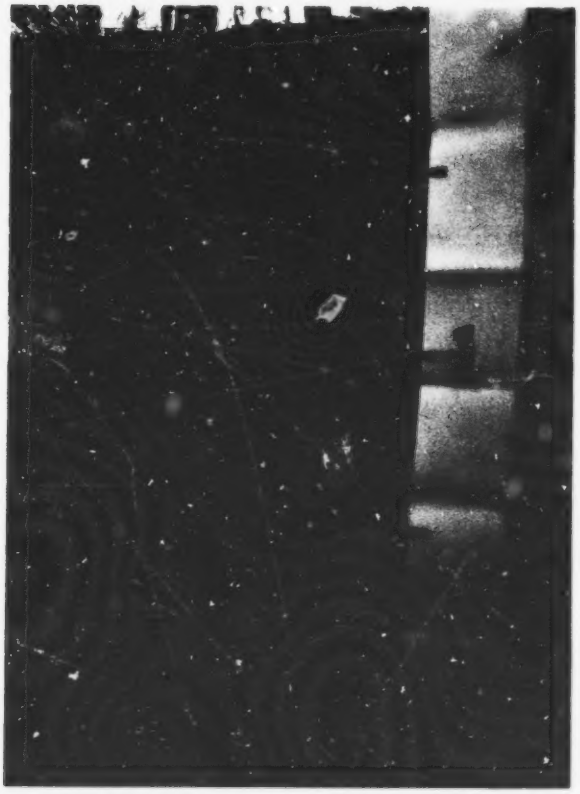
Color Plates
1 to 90

1. Sampled Orthic Eutric Brunisol of the AL2 Ecosite.

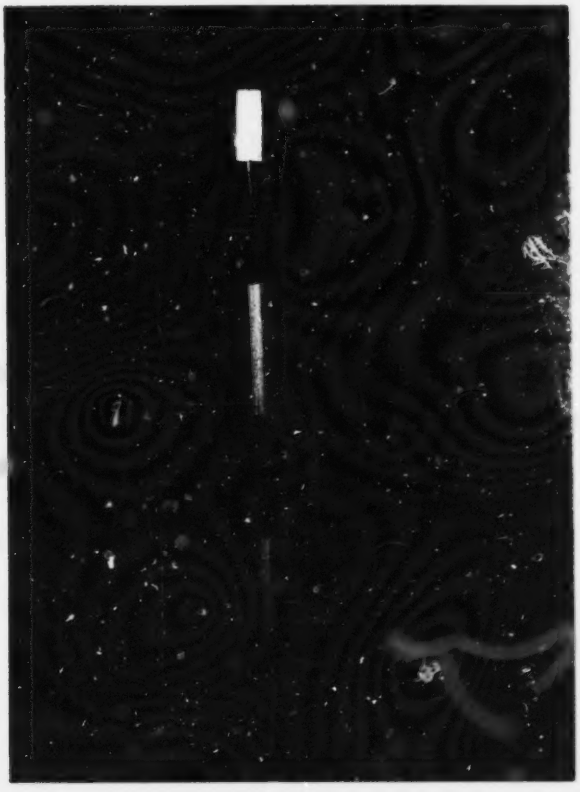
2. Sampled Eluviated Eutric Brunisol of the AT1 Ecosite.

3. Sampled Eluviated Dystric Brunisol of the AZ1 Ecosite.



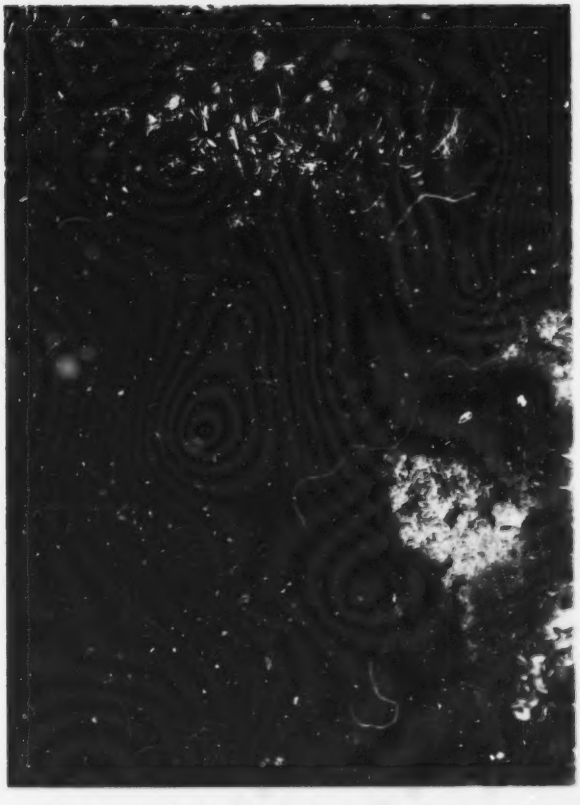
4. Sampled Brunisolic Gray Luvisol of dry upland segments of the BK1 Ecosite.

5. Sampled Eluviated Eutric Brunisol of dry upland segments of the BK4 Ecosite.



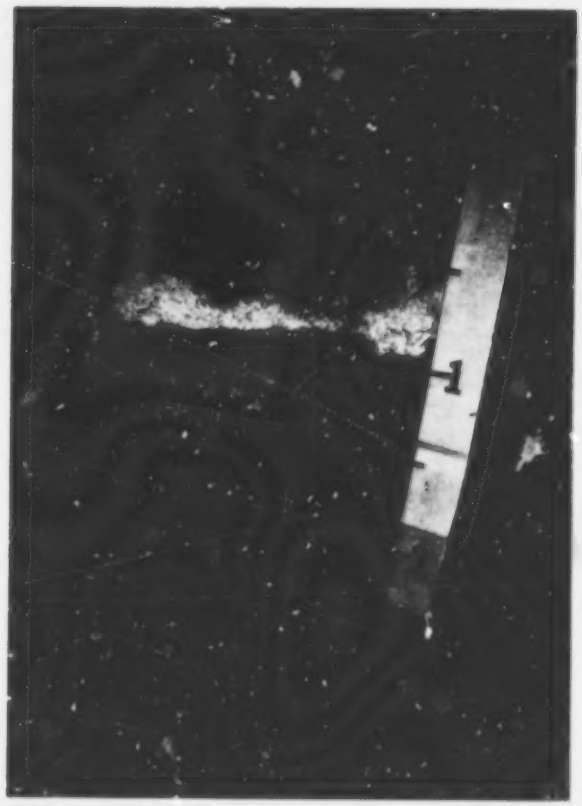
6. Sampled Orthic Eutric Brunisol of the BP1 Ecosite.

7. Sampled Eluviated Eutric Brunisol of the BP2 Ecosite.

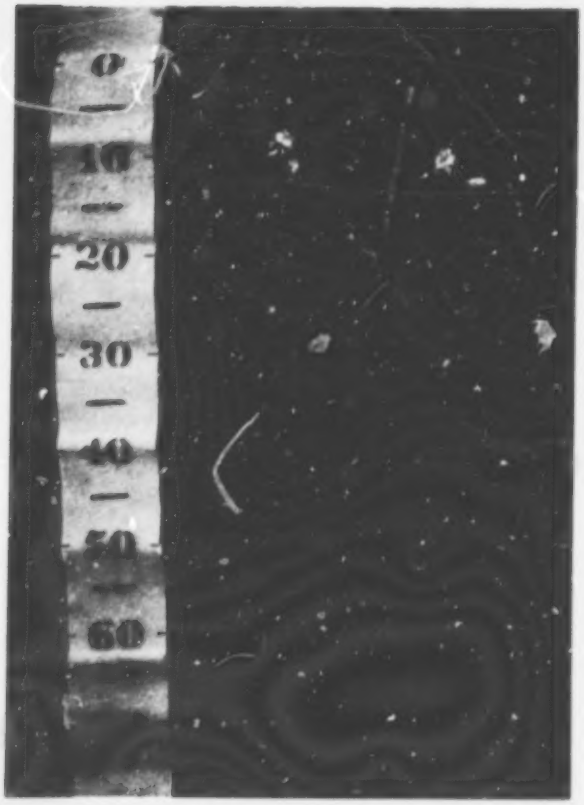


8. Sampled Orthic Melanic Brunisol of the BS1 Ecosite.

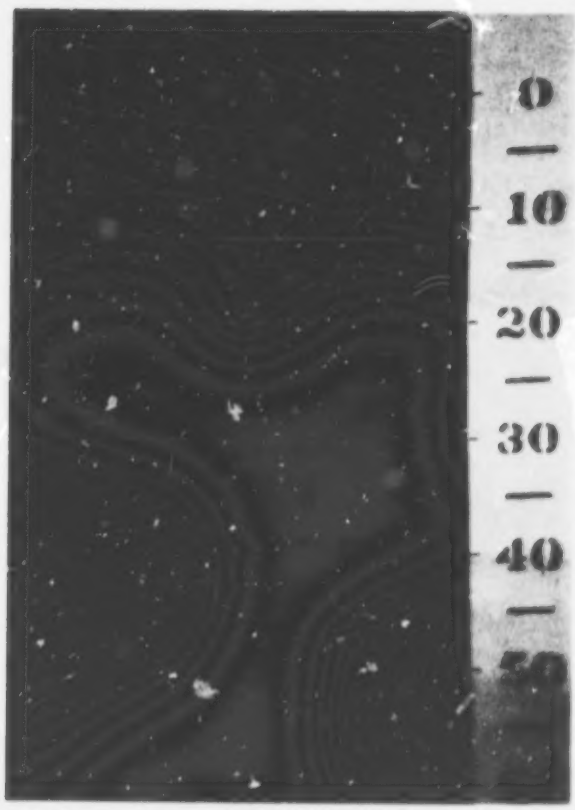
9. Sampled Eluviated Eutric Brunisol of the BV2 Ecosite.



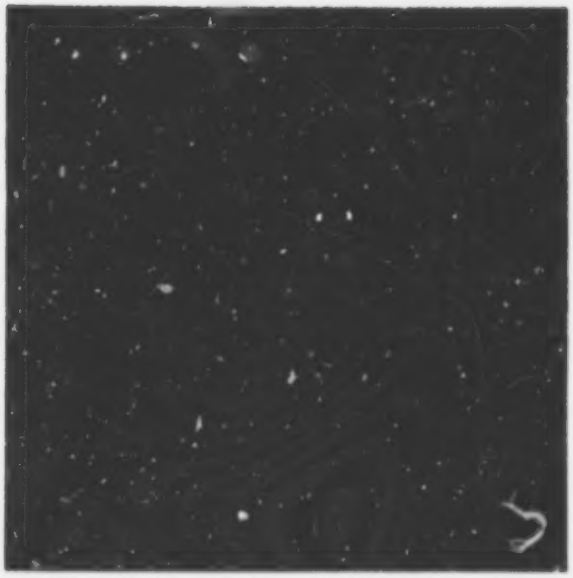
10. Sampled Eluviated Eutric Brunisol of the BY1 Ecosite.



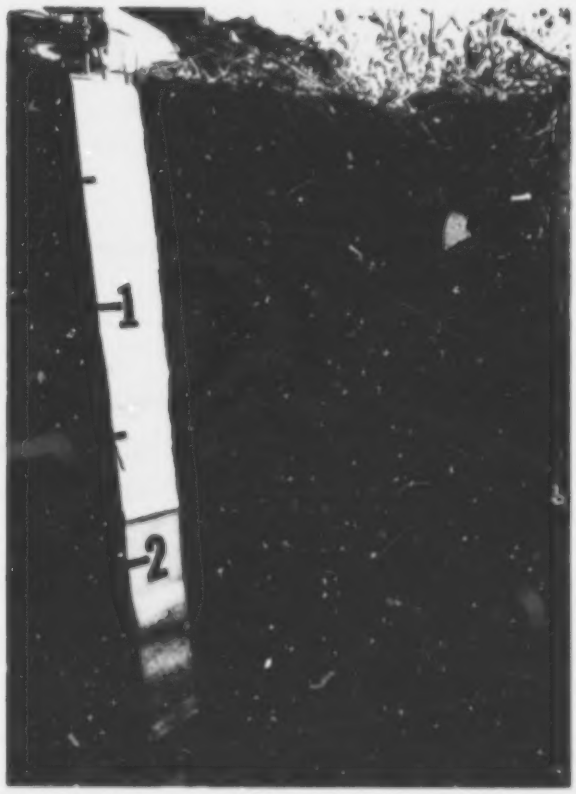
11. Sampled Orthic Eutric Brunisol of the BY2 Ecosite.



12. Sampled Orthic Eutric Brunisol of the BY4 Ecosite.



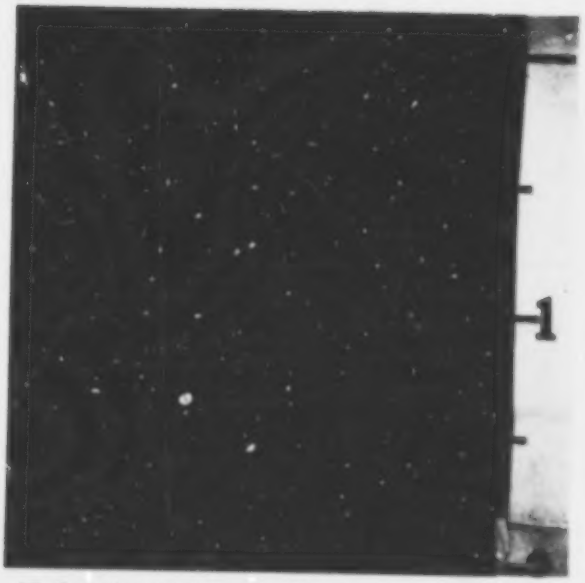
13. Sampled Eluviated Dystric Brunisol, lithic phase, of the BZ2 Ecosite.



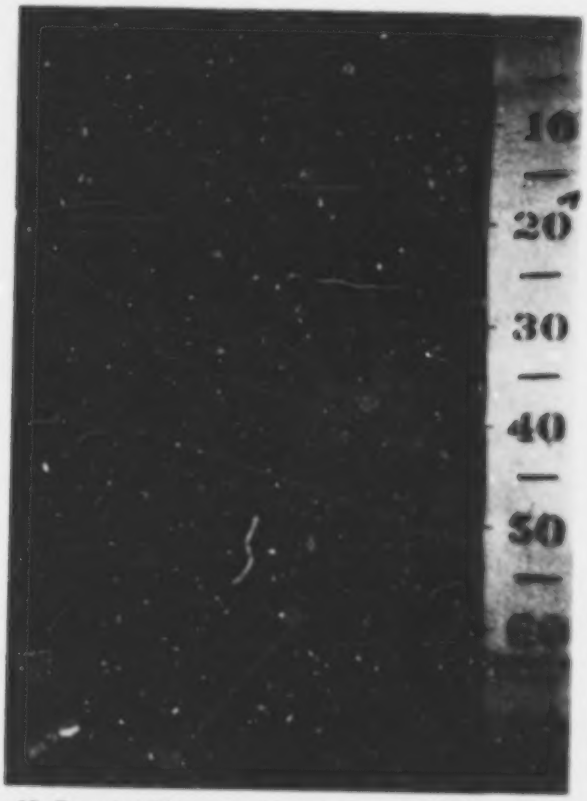
14. Sampled Cumulic Regosol of the CN1 Ecosite.

15. Sampled Orthic Dystric Brunisol of the CP1 Ecosite.

16. Sampled Orthic Ferro-Humic Podzol of the EF1 Ecosite.



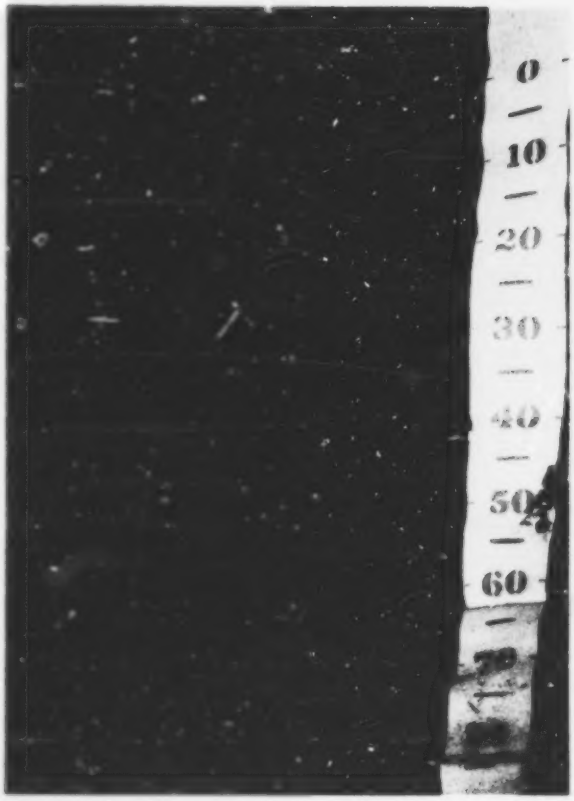
17. Sampled Orthic Dystric Brunisol of the EG4 Ecosite.



18. Sampled Eluviated Dystric Brunisol of the EN1 Ecosite.

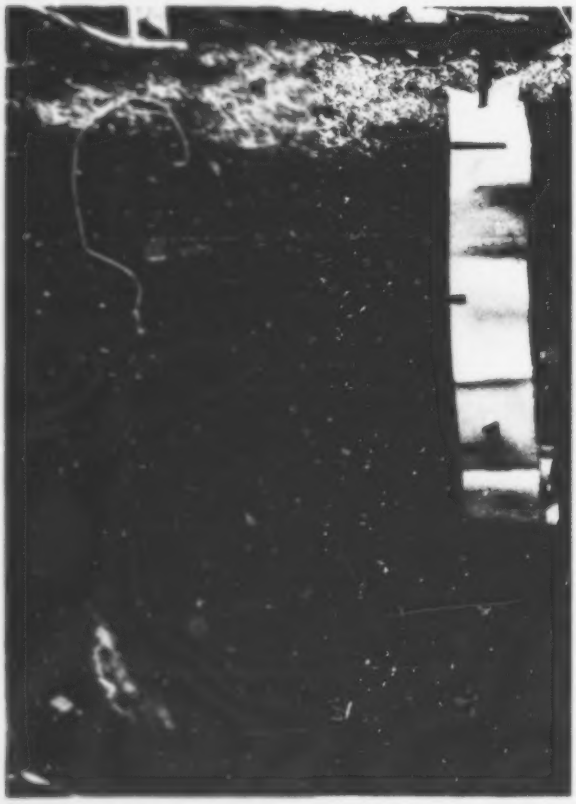
19. Sampled Eluviated Dystric Brunisol of the EN2 Ecosite.

20. Sampled Orthic Eutric Brunisol of the FR1 Ecosite.



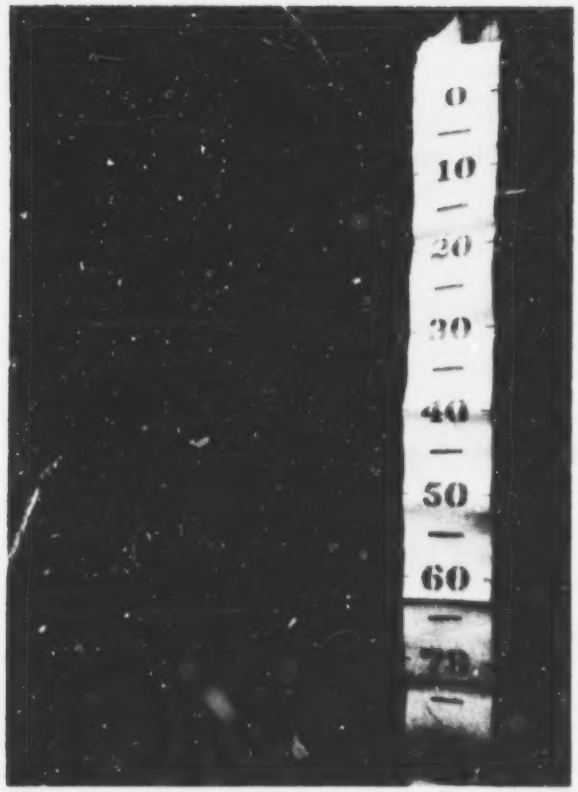
21. Sampled Eluviated Dystric Brunisol of the FV1 Ecosite.

22. Sampled Eluviated Dystric Brunisol of the FV2 Ecosite.

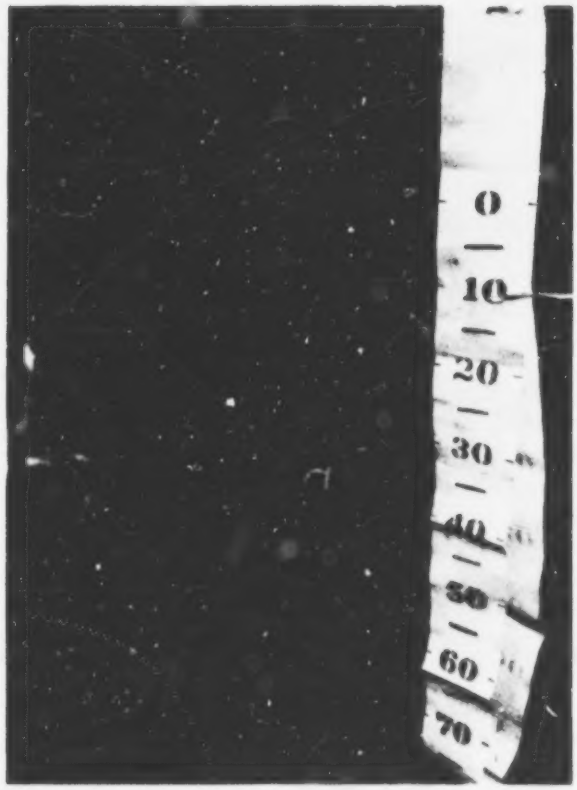


23. Sampled Orthic Eutric Brunisol of the GA1 Ecosite.

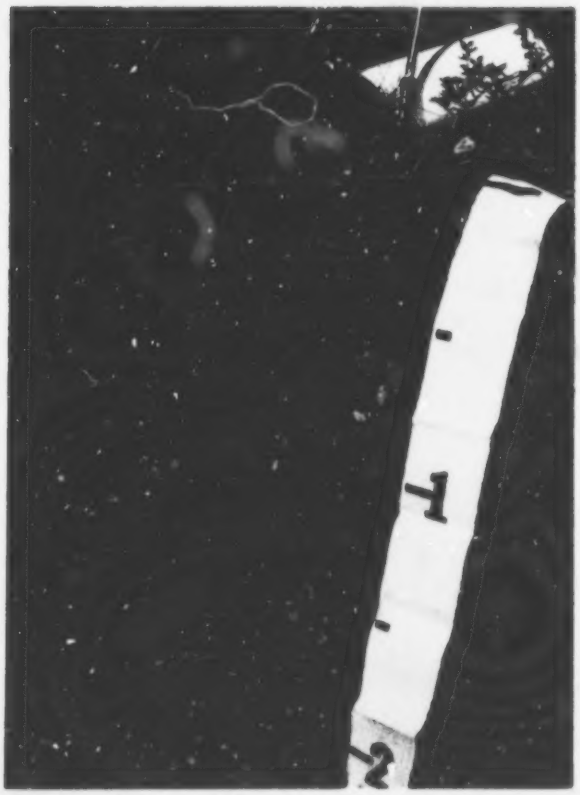
24. Sampled Orthic Regosol of the GT1 Ecosite.



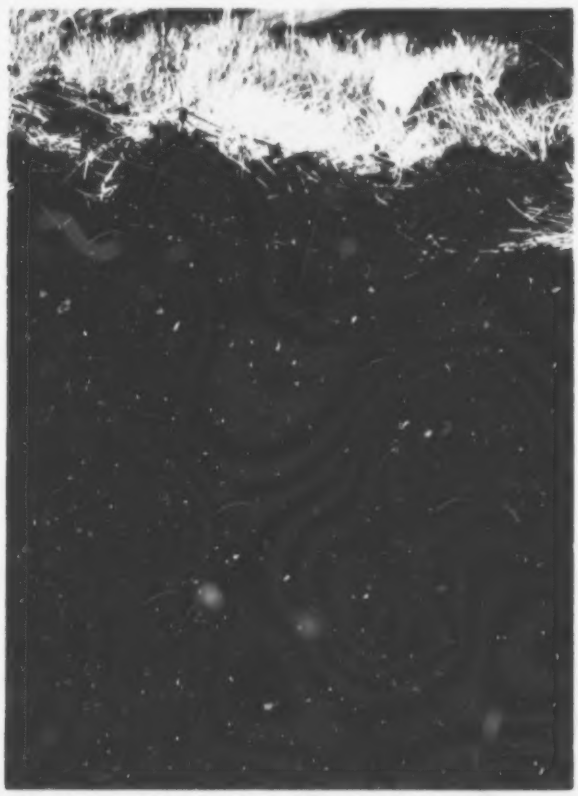
25. Sampled Orthic Humic Regosol of southerly aspect segments of the GT2 Ecosite.



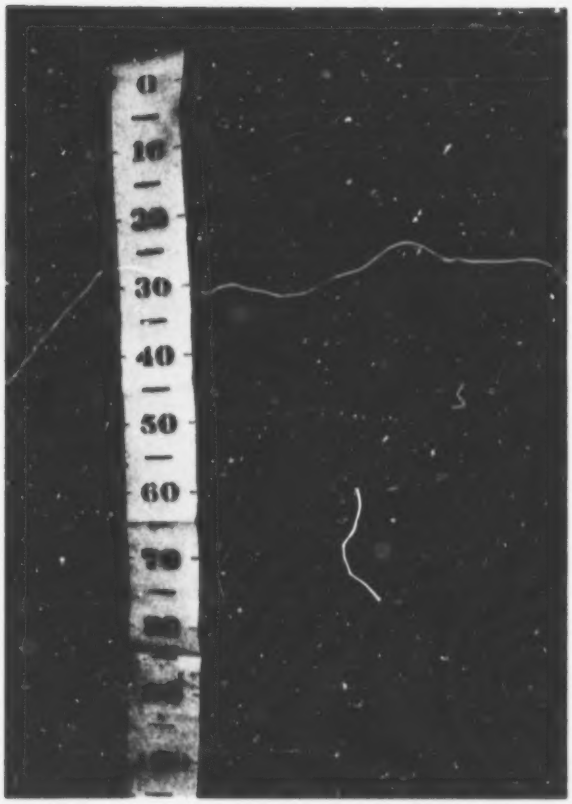
26. Sampled Rego Gleysol of the HC1 Ecosite; an example of stratified fluvial and fluviolacustrine materials.



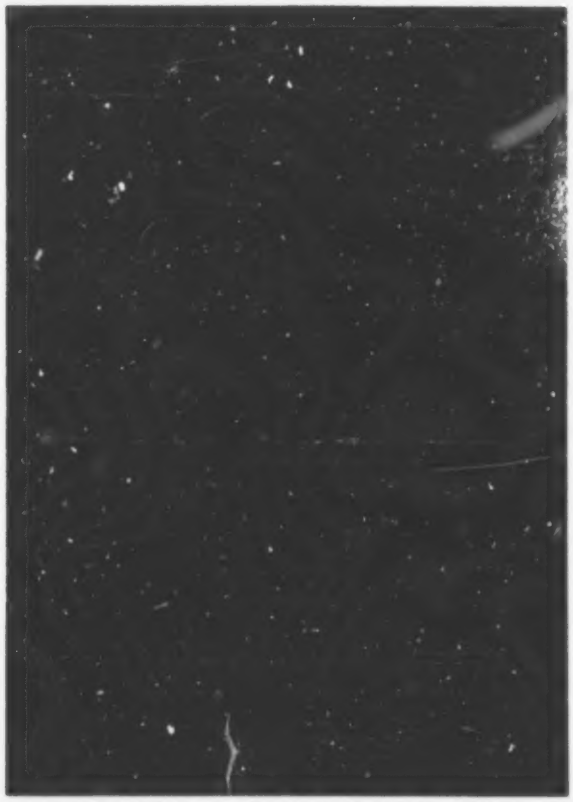
27. Sampled Rego Gleysol of the HC4 Ecosite.



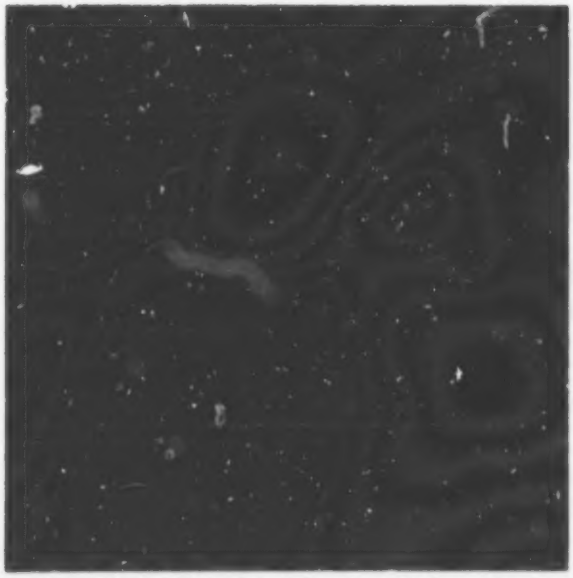
28. Sampled Terric Mesisol of the HC4 Ecosite.



29. Sampled Cumulic Regosol of the HD3 Ecosite.

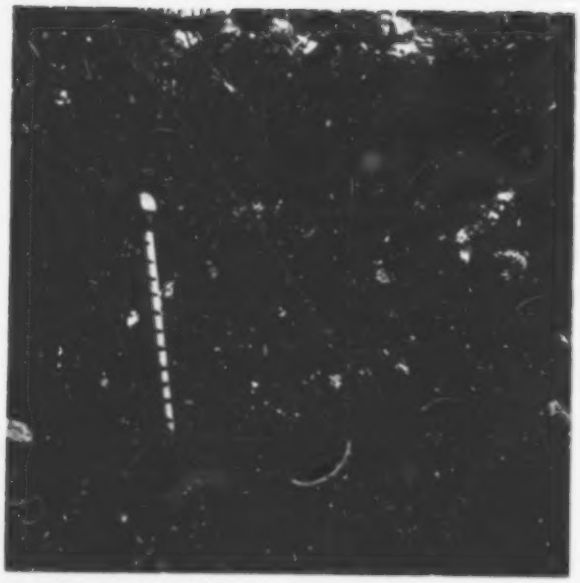


30. Sampled Cumulic Regosol of the HD4 Ecosite.



31. Sampled Orthic Dystric Brunisol, lithic and turbic phases, of the HE1 Ecosite.

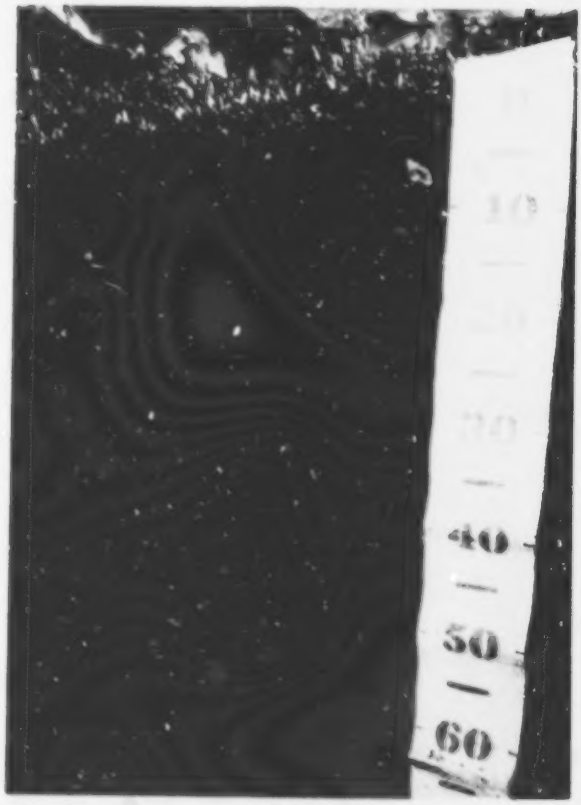
32. Sampled Eluviated Eutric Brunisol of the IB1 Ecosite.



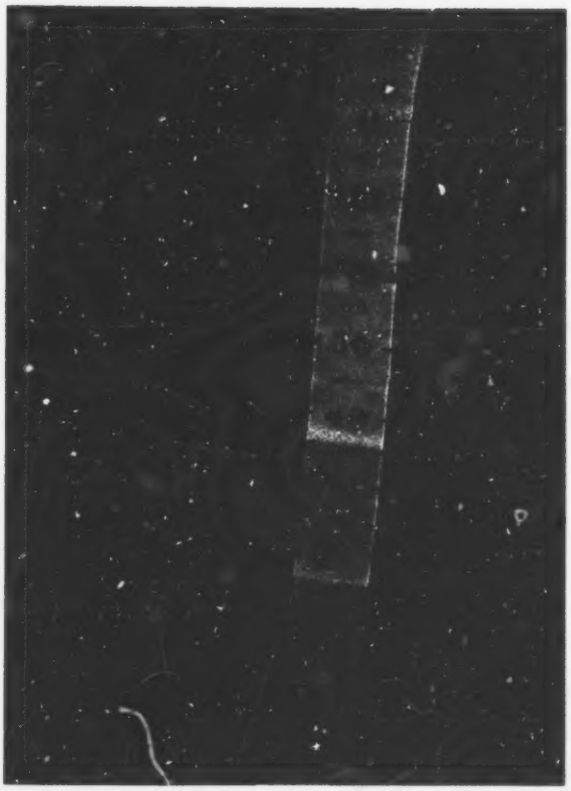
33. Sampled Orthic Regosol of the 1B2 Ecosite.

34. Sampled Eluviated Eutric Brunisol of the 1B3 Ecosite.

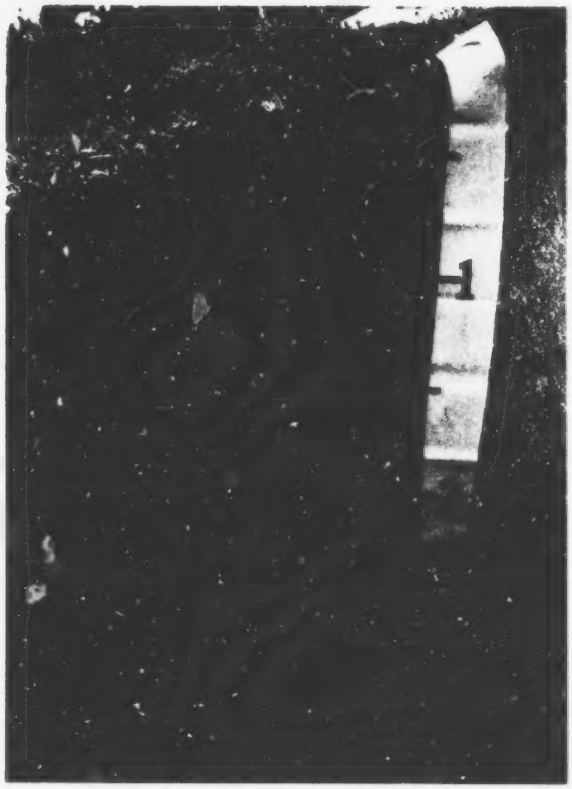
35. Sampled Orthic Dystric Brunisol of the JN1 Ecosite.



36. Sampled Cumulic Humic Regosol of the KA1 Ecosite.

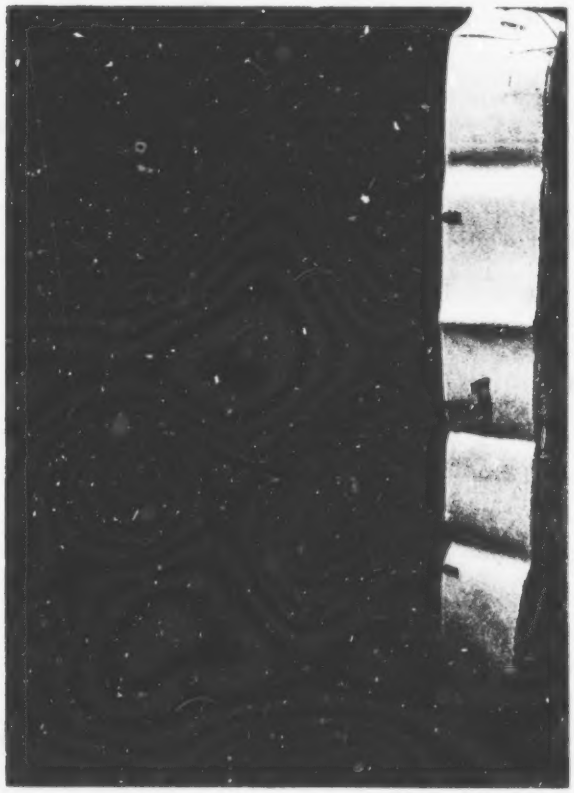


37. Sampled Eluviated Dystric Brunisol of the LV1 Ecosite.



38. Sampled Eluviated Dystric Brunisol of the LV2 Ecosite.

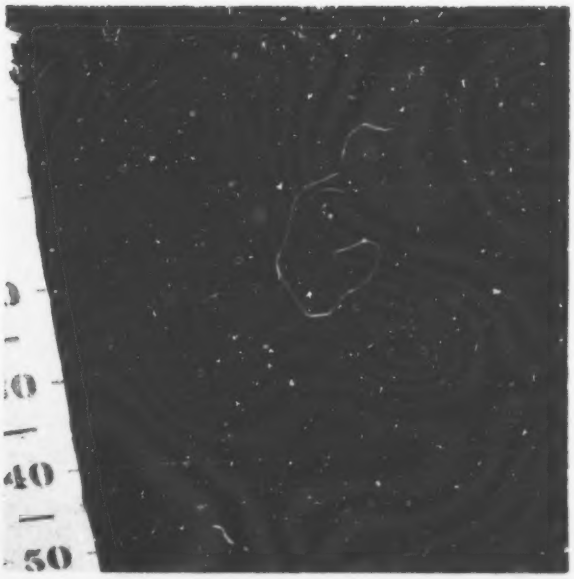
39. Sampled Eluviated Dystric Brunisol of the LV3 Ecosite.



40. Sampled Gleyed Eutric Brunisol of wet depressional segments of the MC1 Ecosite.

41. Sampled Eluviated Dystric Brunisol of the ML2 Ecosite.

42. An Orthic Regosol, turbic phase, on the tract shown in Plate 137.

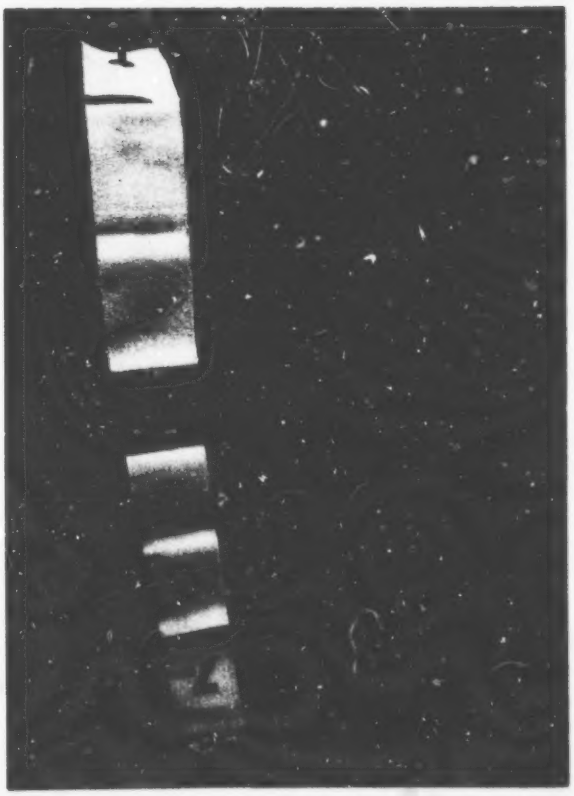


43. An Orthic Melanic Brunisol, turbic phase, showing evidence of solifluction and occurring in the landscape of Plate 138.

44. Sampled Orthic Eutric Brunisol of the MP1 Ecosite.

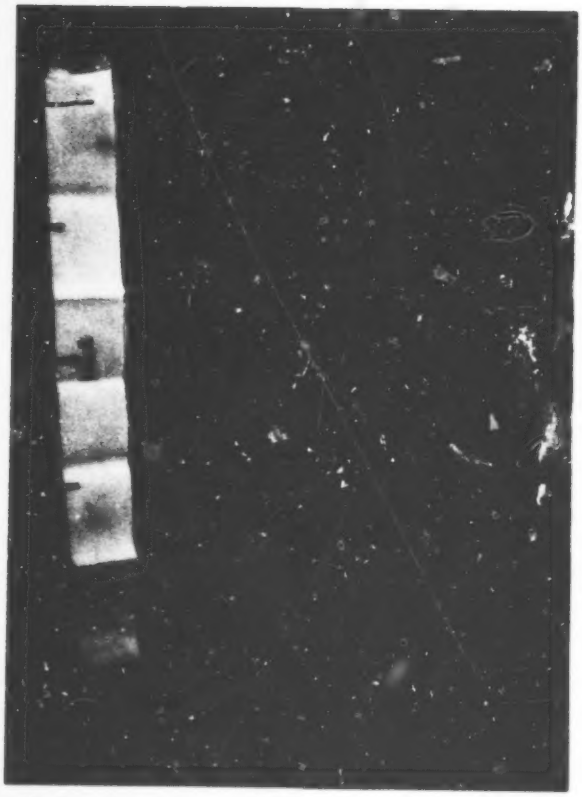
45. Sampled Eluviated Eutric Brunisol of the NG1 Ecosite.

46. Sampled Rego Gleysol of wet depressional segments of the NH1 Ecosite.

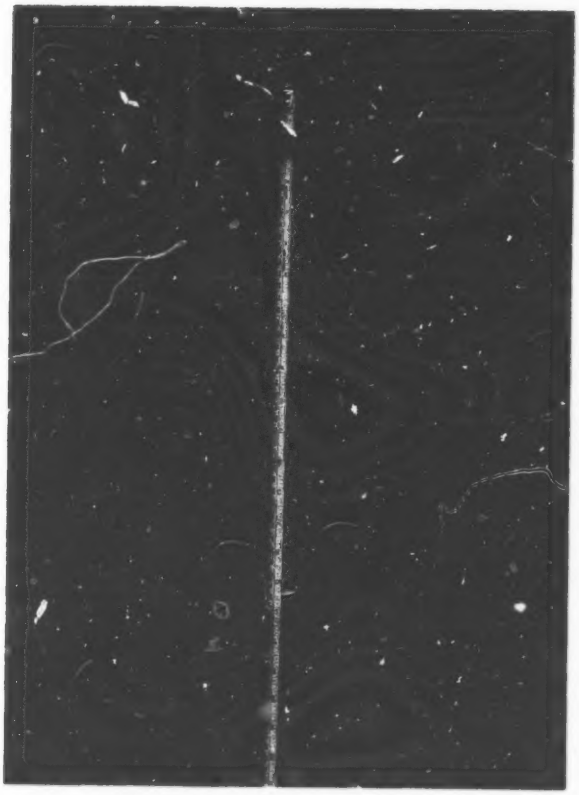


47. Sampled Brunisolic Gray Luvisol from dry upland segments of the NH1 Ecosite.

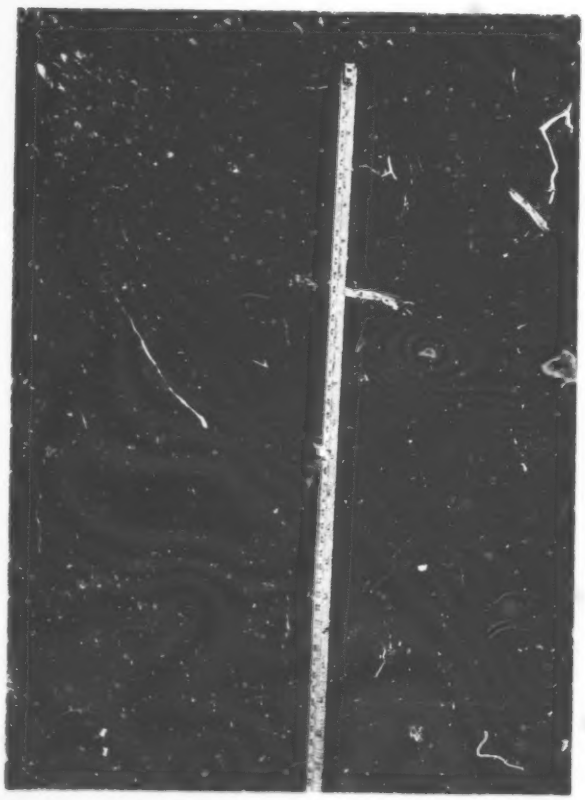
48. Sampled Terric Mesisol of the NT3 Ecosite.



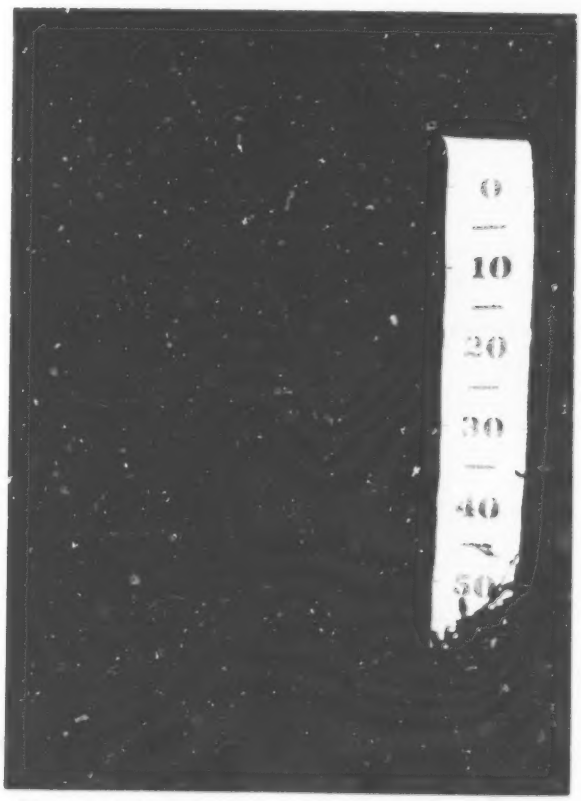
49. Sampled Orthic Eutric Brunisol of the NY1 Ecosite.



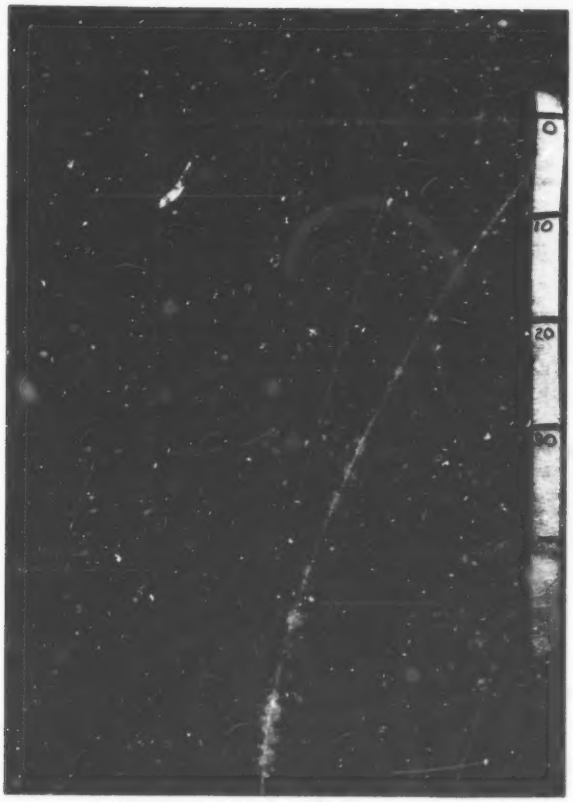
50. Sampled Orthic Eutric Brunisol of northerly aspect segments of the NY3 Ecosite.



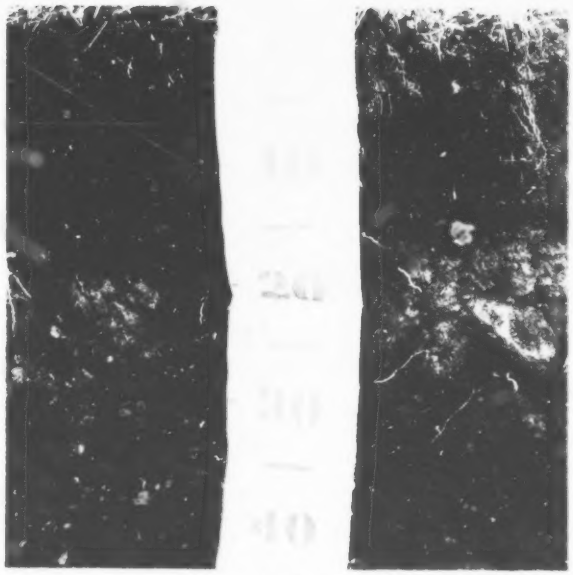
51. Sampled Orthic Regosol of southerly aspect segments of the NY3 Ecosite.



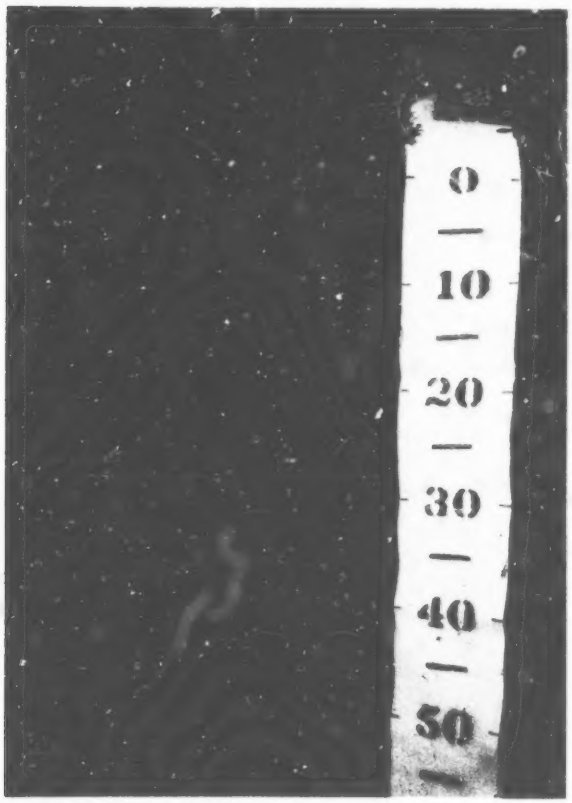
52. Sampled Eluviated Eutric Brunisol of the PL3 Ecosite.



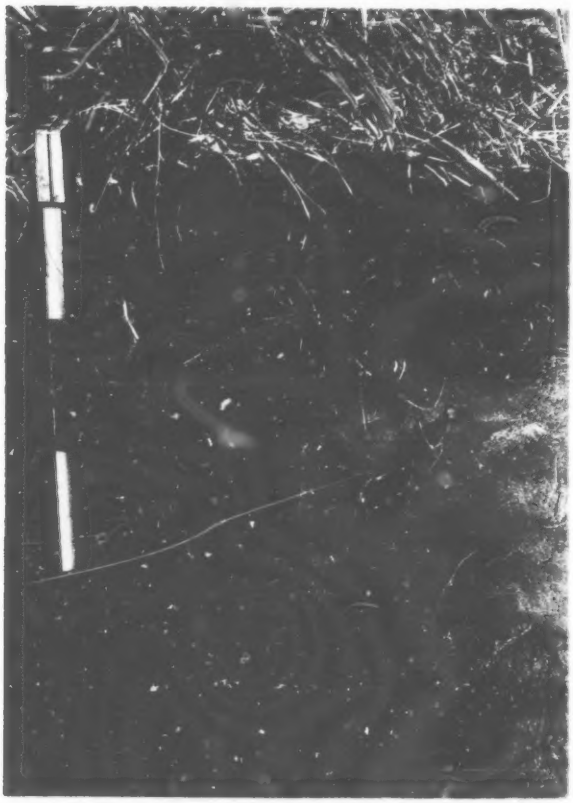
53. Sampled Eluviated Eutric Brunisol of the PL4 Ecosite.



54. Sampled gleyed Podzolic soil of wet depressional segments of the PL5 Ecosite.

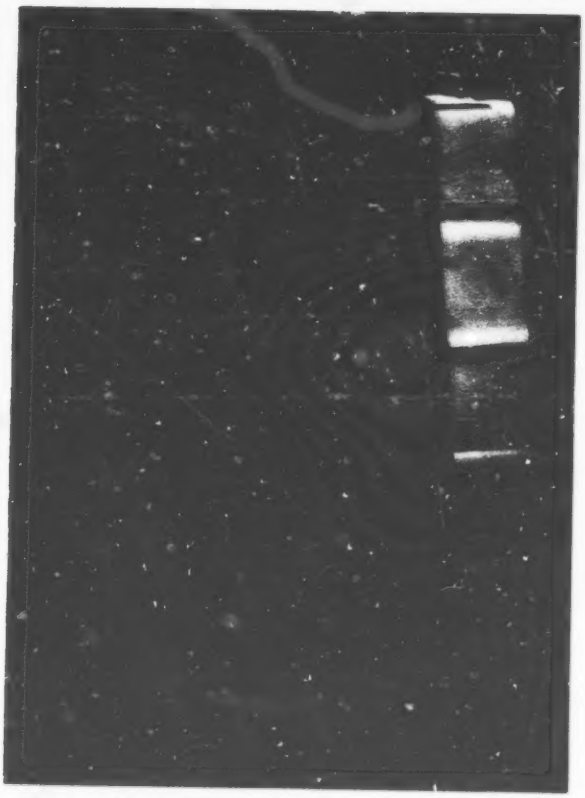


55. Sampled Orthic Regosol of the PP6 Ecosite.



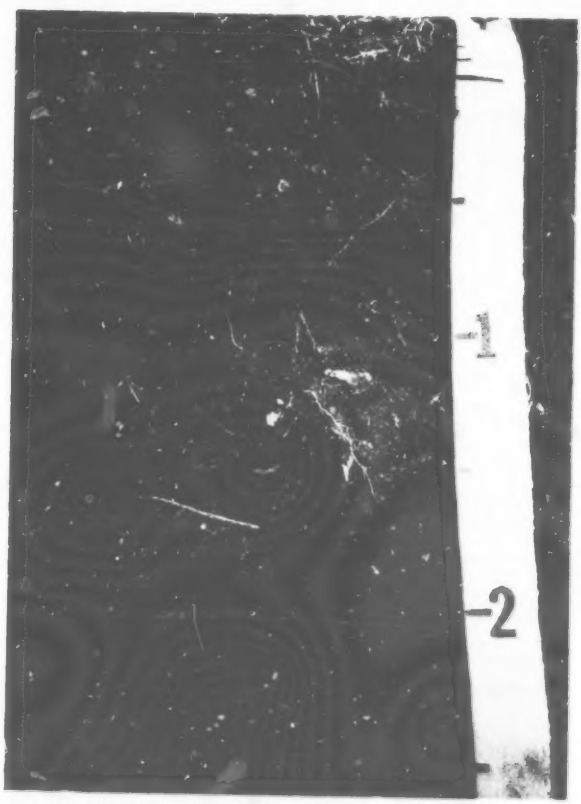
56. Sampled Orthic Humic Regosol of the PP7 Ecosite.

57. Sampled Eluviated Eutric Brunisol of the PR1 Ecosite.

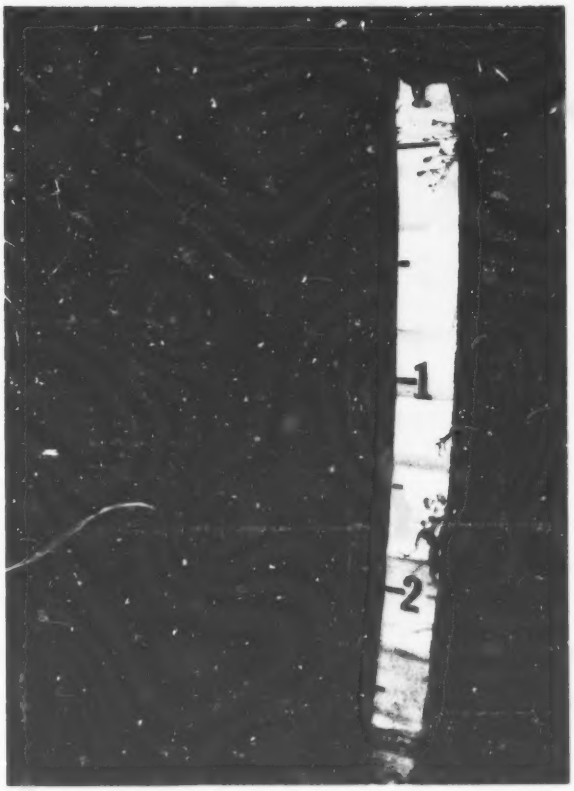


58. Sampled Eluviated Eutric Brunisol of the PR2 Ecosite.

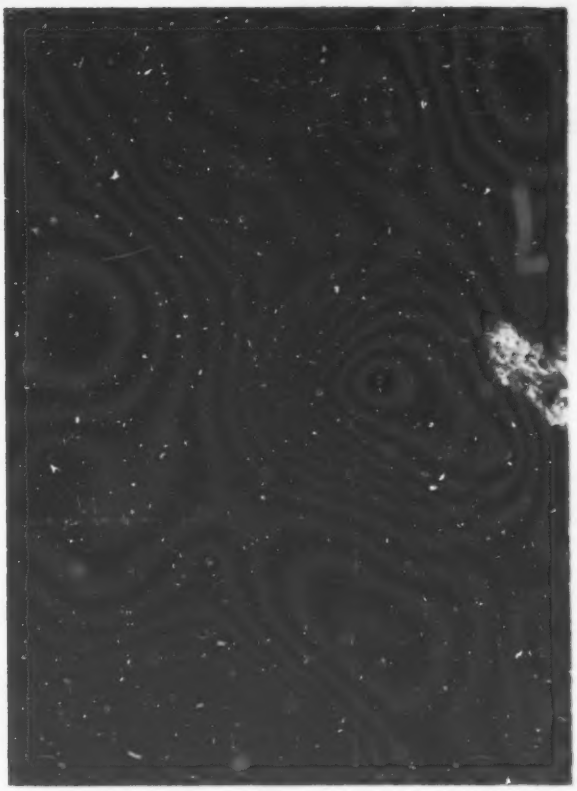
59. Sampled Gleyed Brunisolic Gray Luvisol of the PR3 Ecosite.



60. Sampled Eluviated Eutric Brunisol of southerly aspects of the PR4 Ecosite.

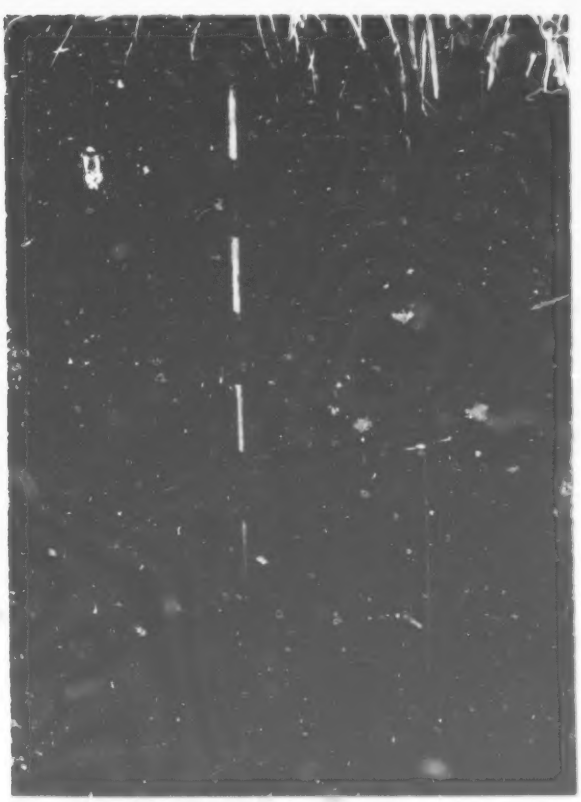


61. Sampled Eluviated Eutric Brunisol of the PR6 Ecosite.



62. Sampled Eluviated Eutric Brunisol of the PT1 Ecosite.

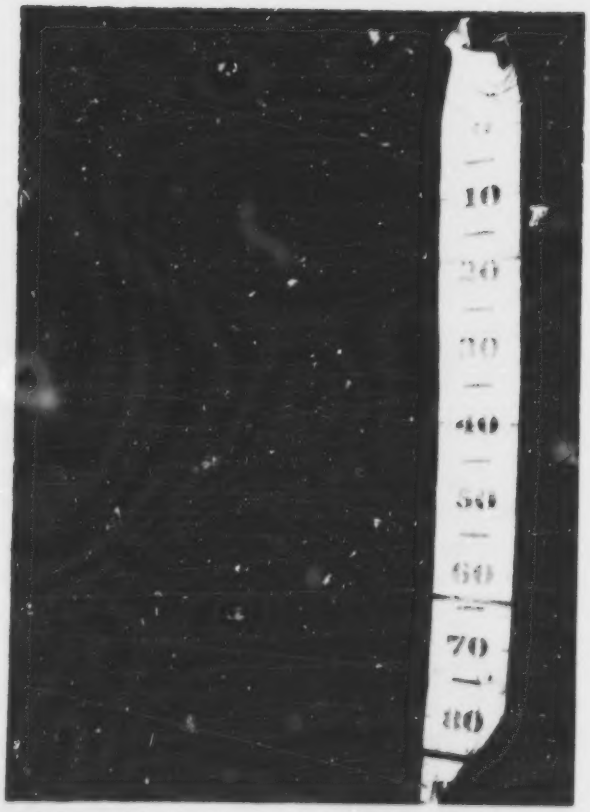
63. Sampled Eluviated Eutric Brunisol of the PT3 Ecosite.



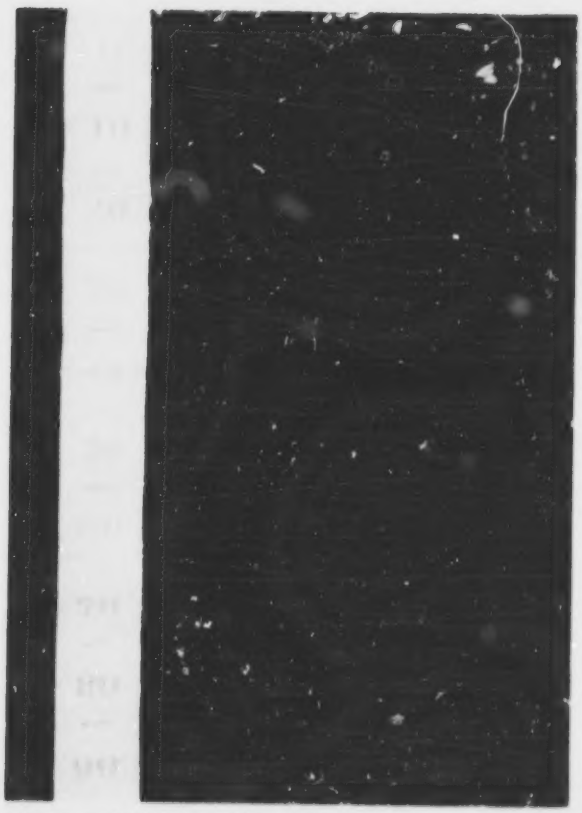
64. Sampled Cumulic Humic Regosol of the SB1 Ecosite.

65. Sampled Orthic Eutric Brunisol of the SB3 Ecosite.

66. Sampled Orthic Eutric Brunisol, lithic phase, of the SB4 Ecosite.



67. Sampled Orthic Eutric Brunisol of the SB5 Ecosite.



68. Sampled Regosolic Static Cryosol of the SF1 Ecosite.

69. Sampled Orthic Gray Luvisol of the SP1 Ecosite.

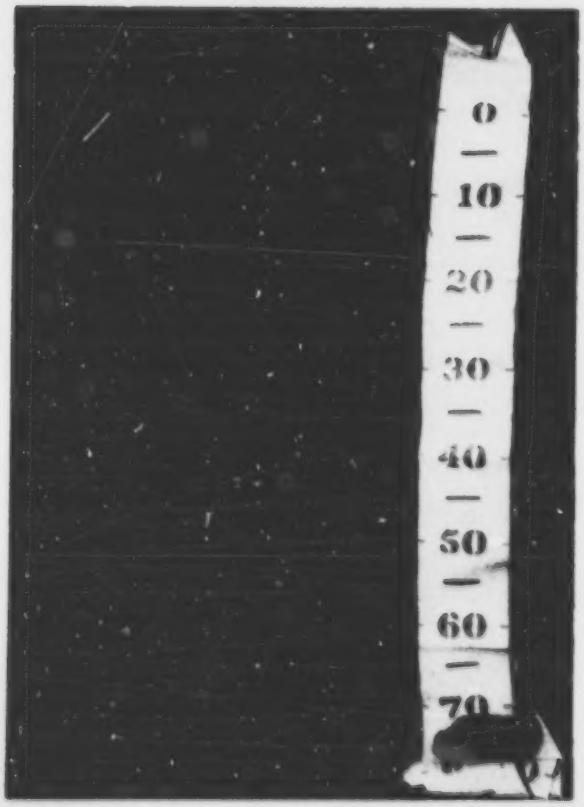
70. Sampled Orthic Gleysol of the SX1 Ecosite.

71. Sampled Gleyed Dystric Brunisol of the SX2 Ecosite.

72. Sampled gleyed Podzolic soil of the SX3 Ecosite.

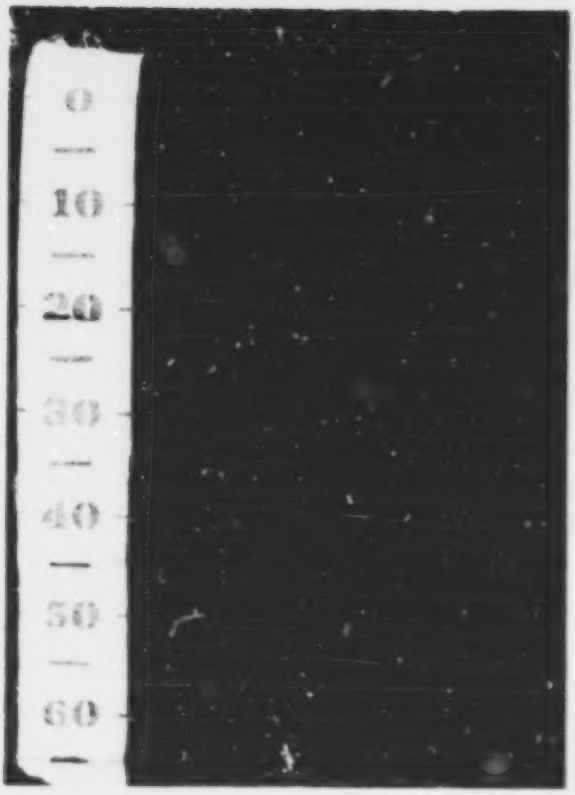
73. Sampled Orthic Regosol of the TA2 Ecosite.

74. A Cumulic Regosol of the TA3 Ecosite in the North Saskatchewan River valley in Banff.

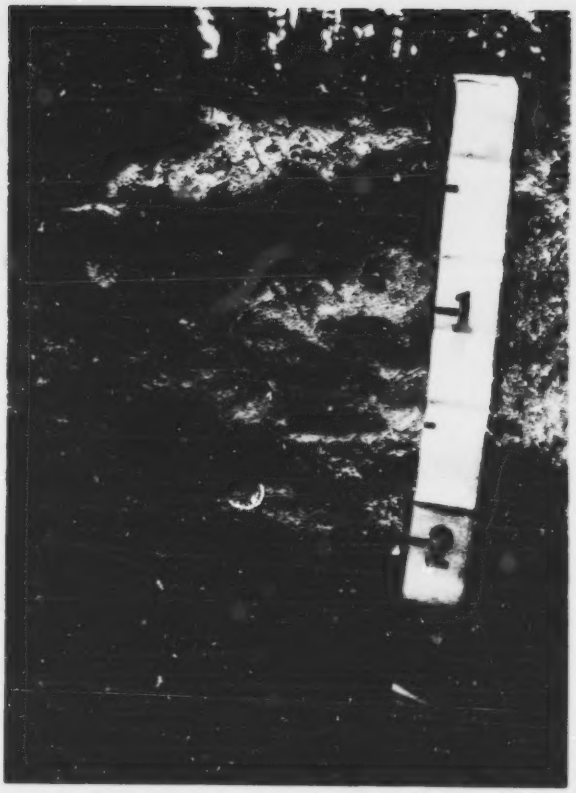


75. Sampled Orthic Dystric Brunisol of the TK1 Ecosite.

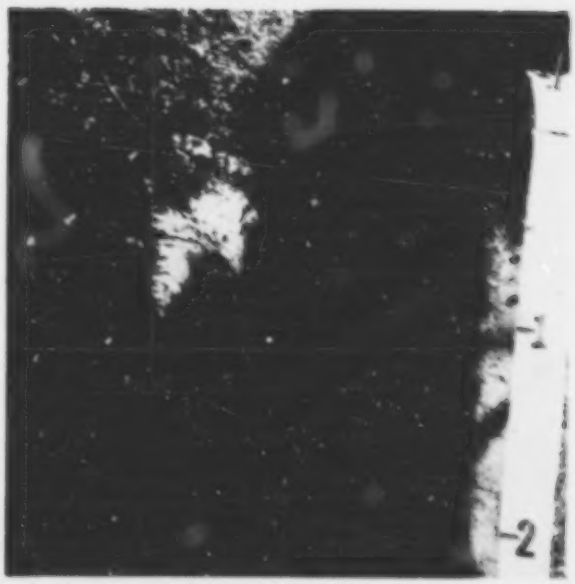
76. Sampled Orthic Eutric Brunisol of the TR1 Ecosite.



77. Sampled Orthic Eutric Brunisol of dry upland segments of the TR2 Ecosite.

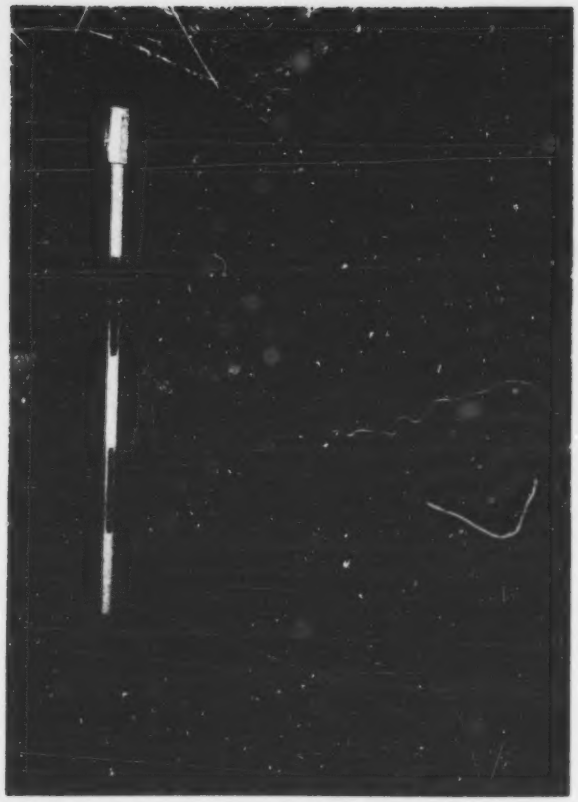


78. Sampled Eluviated Dystric Brunisol of dry upland segments of the TZ2 Ecosite.

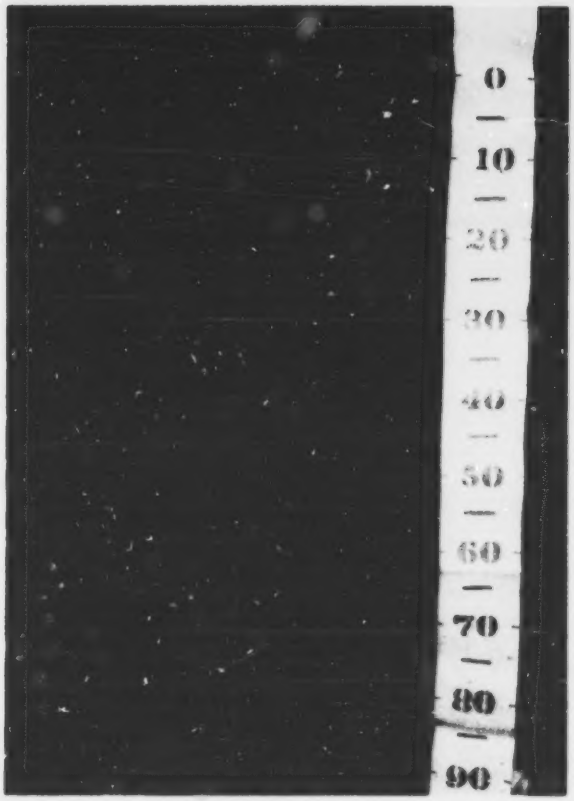


79. Sampled Eluviated Dystric Brunisol of the VD1 Ecosite.

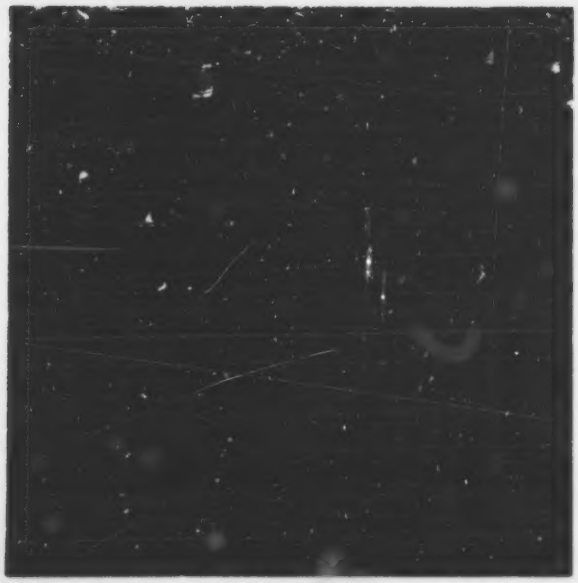
80. Sampled Rego Gleysol of the VL4 Ecosite.



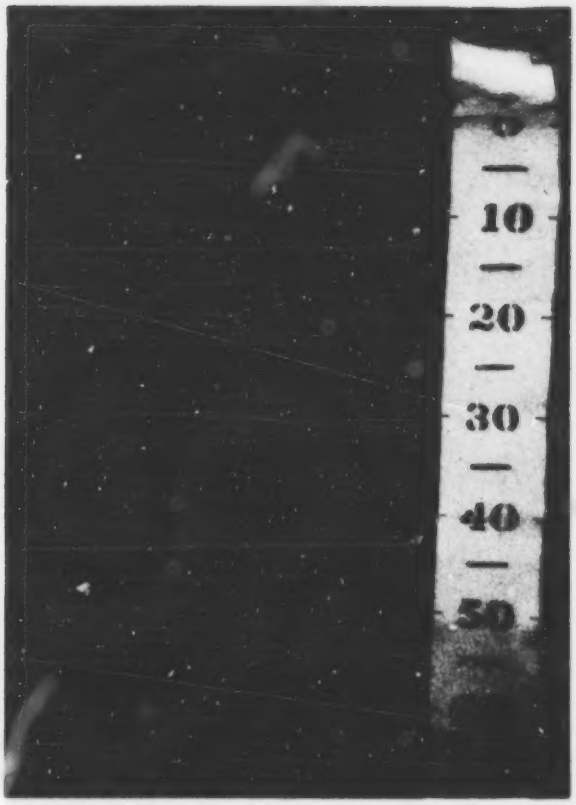
81. Sampled Rego Gleysol of the VI.5 Ecosite.



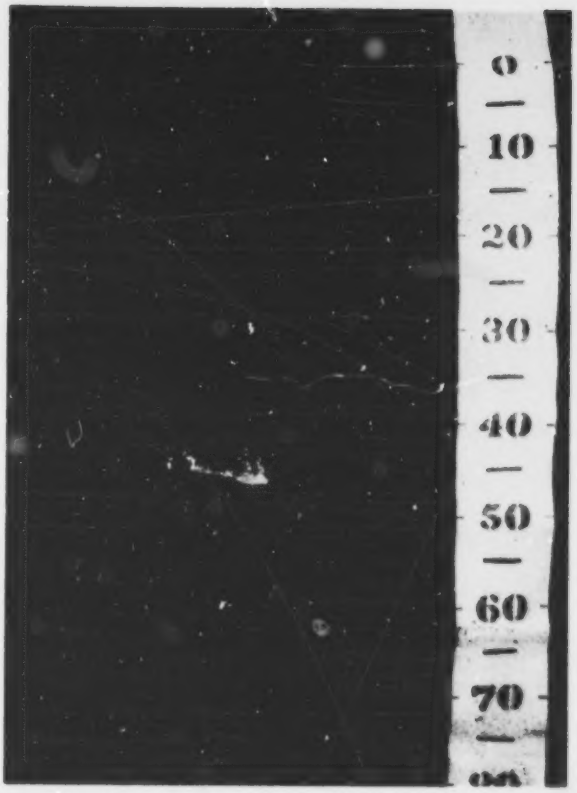
82. Sampled Orthic Eutric Brunisol of the WF1 Ecosite.



83. Sampled Cumulic Humic Regosol of the WF2 Ecosite.

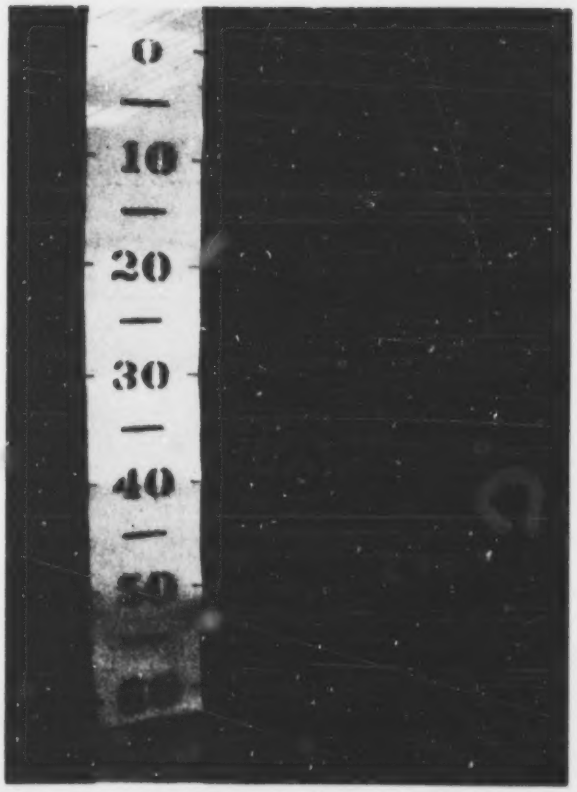


84. Sampled Orthic Eutric Brunisol of the WF3 Ecosite.

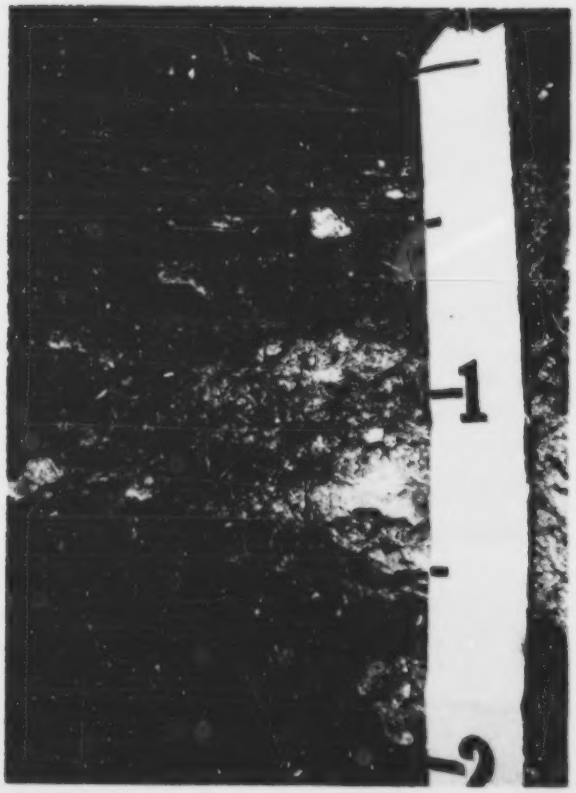


85. Sampled Orthic Eutric Brunisol of the WF4 Ecosite.

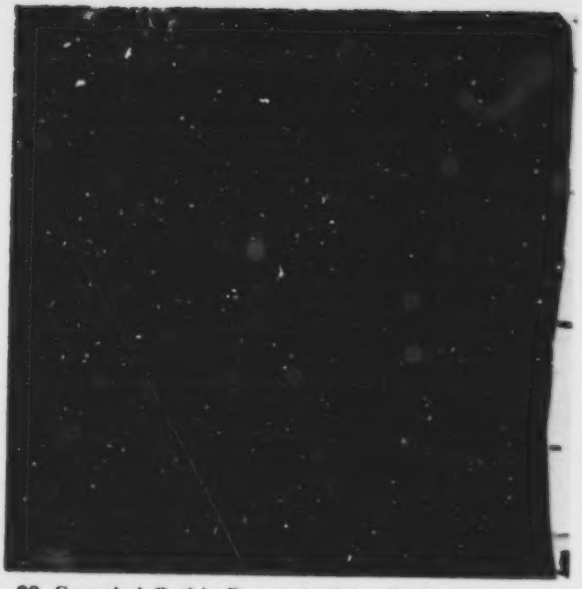
86. Sampled Orthic Melanic Brunisol of the WF7 Ecosite.



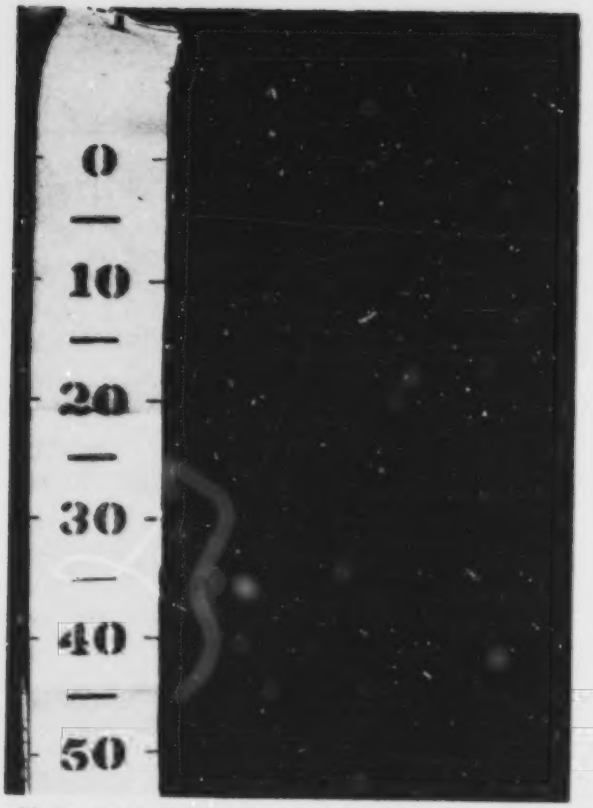
87. Sampled Orthic Sombric Brunisol of the WH1 Ecosite.



88. Sampled Orthic Dystric Brunisol of the WH3 Ecosite.



89. Sampled Orthic Regosol of the WH5 Ecosite.



90. Sampled Orthic Humic Regosol of the WW1 Ecosite.

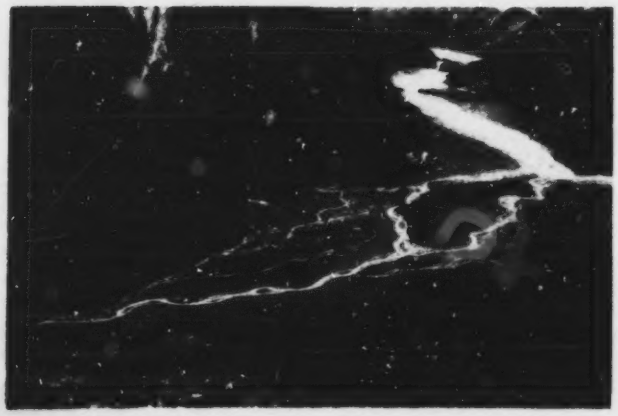
Plates
1 to 201

1. Postglacial residual genetic material on Copper Mountain, Banff.

2. Dip slope failure near Nigel Pass in Jasper, with potential for further failure.

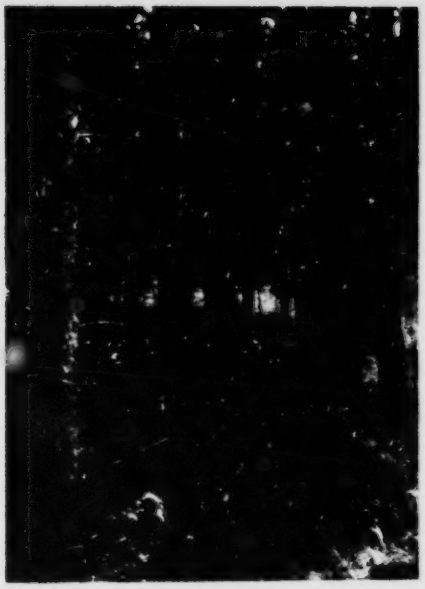
3. Debris cones on a landslide of unconsolidated material; near Dolomite Creek, Banff.

4. An exposure of Ice Contact Stratified Drift B. Note vertical and lateral textural variability, the coarse textures being associated with the gravelly surface and the pocket at the left (under spade), medium textures with the unsorted material. Near Mistaya Canyon bridge, Banff.



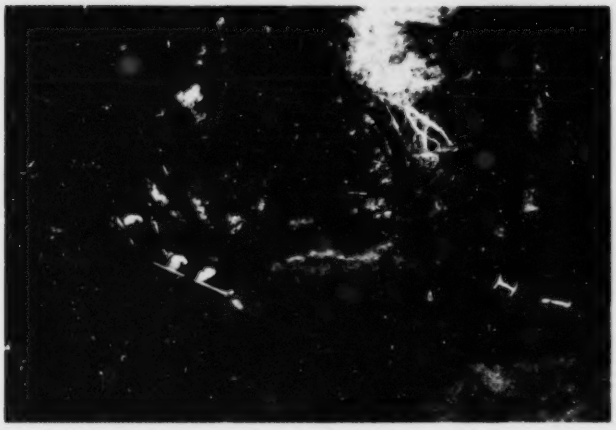
5. An abrupt vegetation boundary bordering an active glaciofluvial area at the confluence of Conway, Forbes, and Freshfield Creeks with the Howse River, Banff.

6. *Pseudotsuga menziesii/ Elymus innovatus* (C1) v.t. at 1160 m in central Jasper (IC5022.1).

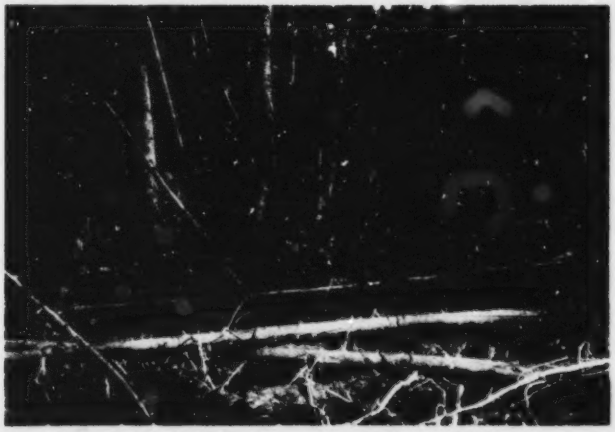


7. *Picea glauca/ Thuidium abietinum* (C2) v.t. at 1100 m on a gentle northwest aspect near the east gate of Jasper (JC7009.1)

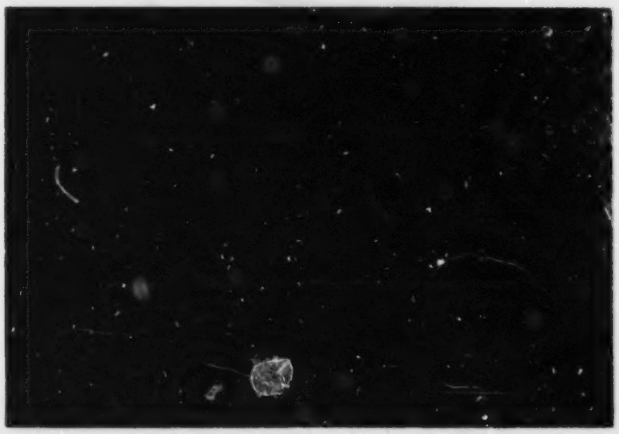
8. *Pinus contorta/ Juniperus communis/ Arctostaphylos uva-ursi* (C3) v.t. at 1490 m in southern Banff (JD7114).



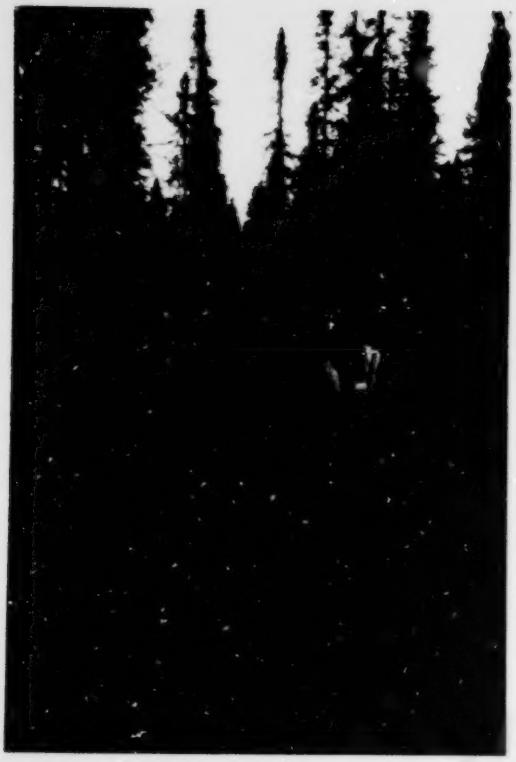
9. *Picea glauca/ Rosa acicularis/ Equisetum arvense* (C4) v.t. at 1000 m in central Jasper (JM8119).



10. *Picea glauca-Pseudotsuga menziesii/ Hylocomium splendens* (C5) v.t. in northern Banff.

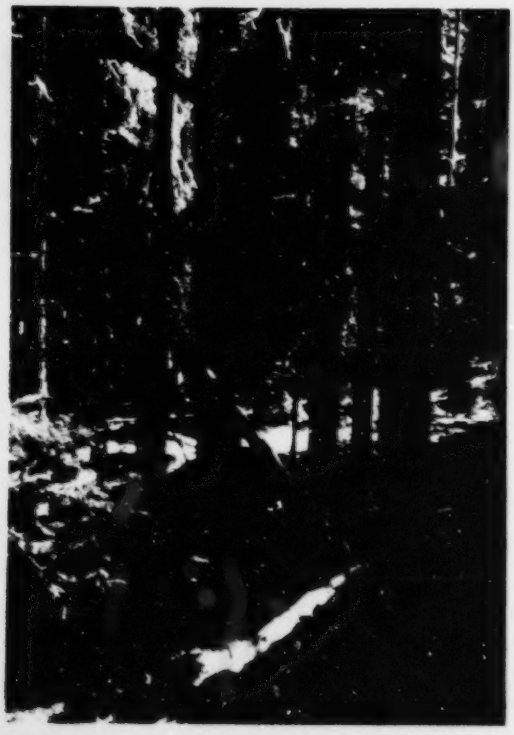


11. *Pinus contorta/ Shepherdia canadensis/ Aster conspicuus* (C6) v.t. at 1750 m in central Banff (PA8153).

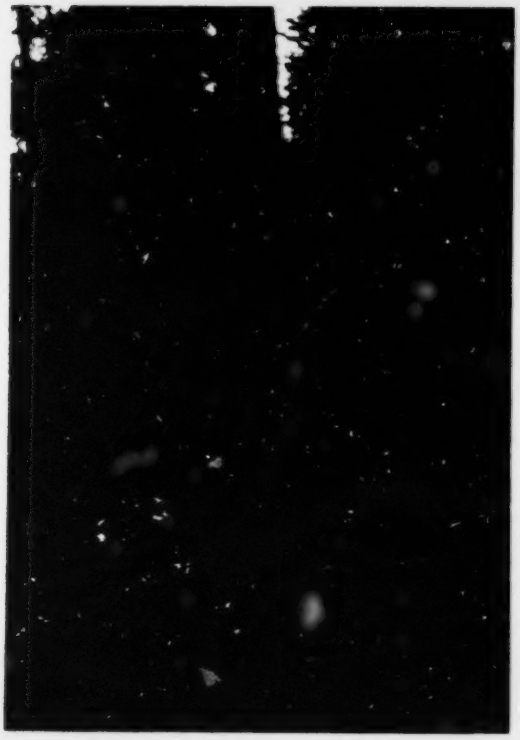


12. *Picea mariana-Pinus contorta/Salix myrtillifolia/Carex vaginata* (C8) v.t. at 1230 m in central Jasper (JC6008).

13. *Pinus contorta/Alnus crispa/Hylocomium splendens* (C10) v.t. at 1420 m on a moderate easterly aspect in central Jasper (1C5072).



14. *Pinus contorta/Hylocomium splendens* (C11) v.t. at 1320 m in central Jasper (JC6004).



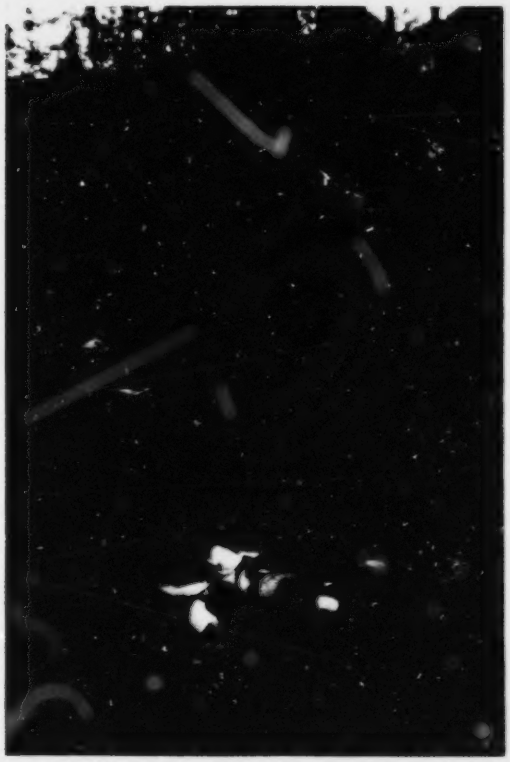
15. *Picea engelmannii-Abies lasiocarpa/Hylocomium splendens* (C13) v.t. in southern Jasper.

16. *Picea engelmannii-Abies lasiocarpa/ Menziesia glabella* (C14) v.t. at 1760 m in northern Banff (PA7054).

17. *Picea engelmannii-Abies lasiocarpa/ Vaccinium scoparium* (C15) v.t. at 2080 m in northern Banff (JD9077).

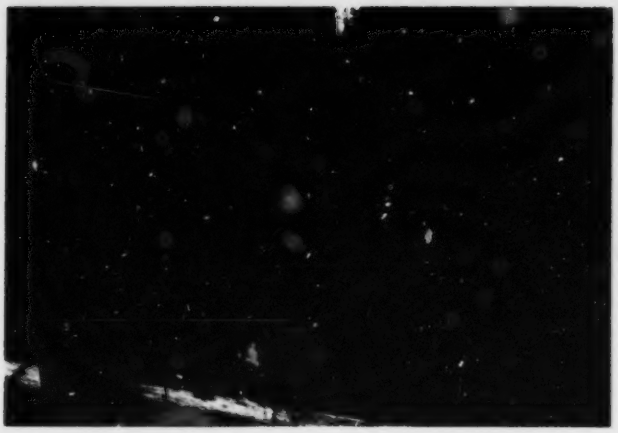
18. *Populus tremuloides/ Elymus innovatus-Lathryus ochroleucus* (C16) v.t. at 1450 m in southern Banff (PA8001.5).

19. *Populus balsamifera/ Shepherdia canadensis* (C17) v.t. at 1230 m near the east gate of Jasper (JC7011).



20. *Pinus contorta/ Shepherdia canadensis/ Vaccinium scoparium* (C18) v.t. at 1500 m in northern Banff (JC6011).

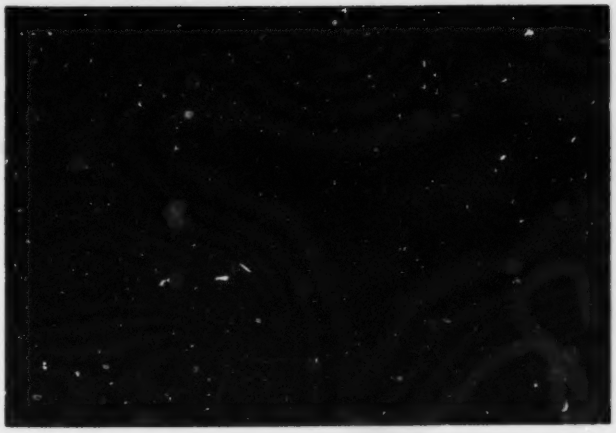
21. *Pinus contorta/ Shepherdia canadensis/ Linnaea borealis* (C19) v.t. at 1480 m in southern Banff (JE8004).



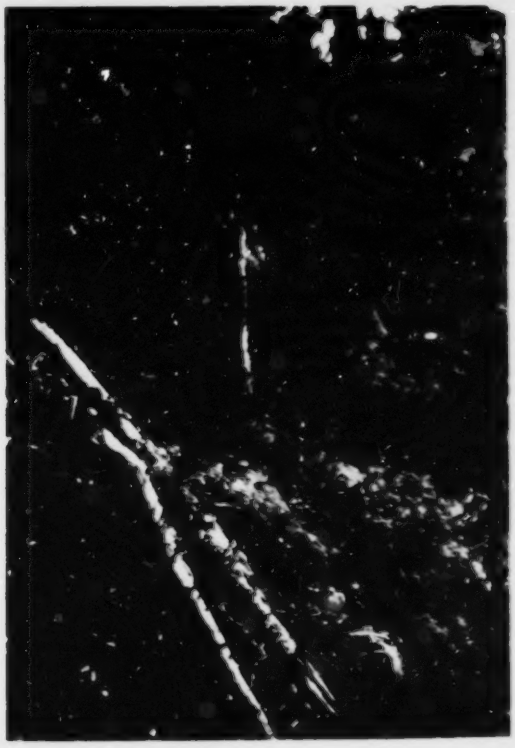
22. *Pinus contorta/ Menziesia glabella/ Vaccinium scoparium* (C20) v.t. at 1530 m in western Jasper (JD9030).

23. *Picea engelmannii-Abies lasiocarpa/ Vaccinium membranaceum/ Barbilophozia lycopodioides* (C21) v.t. at 1890 m in northern Banff (JC6112).

24. *Populus tremuloides/ Elymus innovatus-Aster conspicuus* (C22) v.t. on a steep west aspect in northern Banff (1C6022).

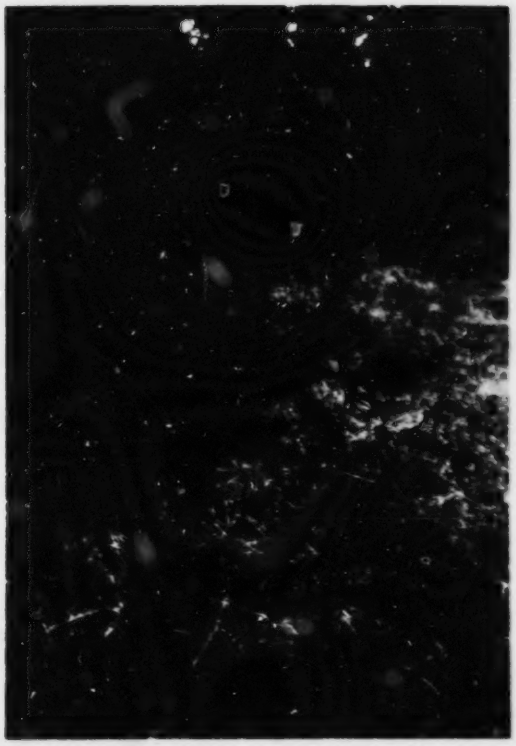


25. *Larix lyallii-Abies lasiocarpa/ Vaccinium scoparium-Antennaria lanata* (C23) v.t. at 2250 m in central Banff.



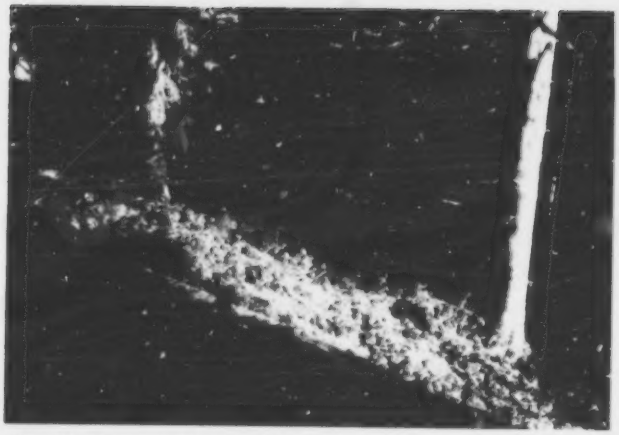
26. *Picea engelmannii-Abies lasiocarpa/ Salix vestita/ Cassiope tetragona* (C24) v.t. at 2020 m on a steep north aspect in northern Jasper (PA9134).

27. *Picea glauca/ Shepherdia canadensis/ Thuidium abietinum* (C26) v.t. at 1470 m in northern Banff (PA7059).

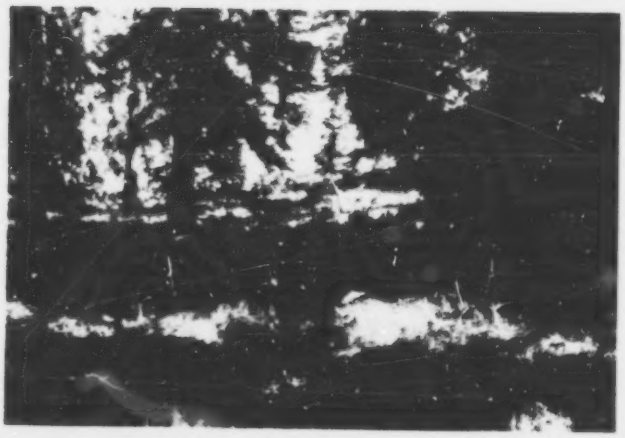


28. *Picea glauca/ Rosa acicularis/ Thuidium abietinum* (C27) v.t. at 1000 m near the east gate of Jasper (JM8001).

29. *Pinus contorta/ Ledum groenlandicum* (C29) v.t. at 1590 m in southern Banff (PA7012).



30. *Picea engelmannii-Abies lasiocarpa/ Ledum groenlandicum/ Empetrum nigrum* (C30) v.t. at 1510 m in central Jasper (JM8114).



31. *Picea engelmannii-Abies lasiocarpa/ Elymus innovatus-Arnica cordifolia-Linnaea borealis/ Hylocomium splendens* (C31) v.t. at 1510 m in northern Jasper (PA9031).

32. *Picea engelmannii/ Equisetum arvense/ Hylocomium splendens* (C32) v.t. at 1670 m in northern Jasper (PA9051).

33. *Picea engelmannii/ Elymus innovatus* (C33) v.t. at 1990 m in eastern Banff (JE8015).

34. *Picea engelmannii-Abies lasiocarpa/ Phyllodoce glanduliflora/ Hylocomium splendens* (C34) v.t. at 1900 m in western Jasper (PA9113).

35. *Pinus contorta-(Picea engelmannii)/ Empetrum nigrum/ Cladonia mitis* (C35) v.t. in northern Jasper.

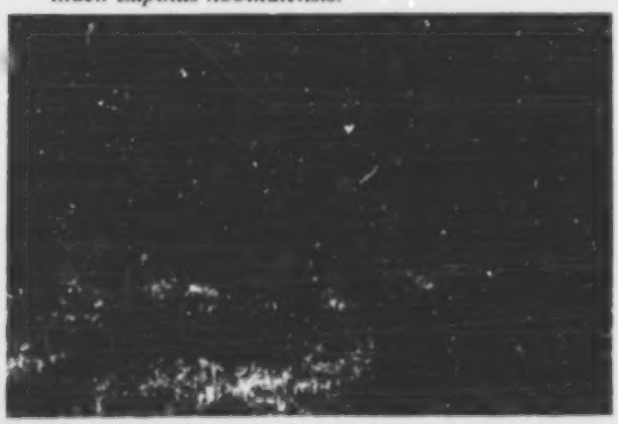
36. *Pinus flexilis-Pseudotsuga menziesii/ Juniperus scopulorum/ Arctostaphylos uva-ursi* (02) v.t. at 1420 m in southern Banff (JC8001).

37. *Picea glauca/ Potentilla fruticosa/ Arctostaphylos uva-ursi* (03) v.t. at 1000 m near the east gate of Jasper (SJ8003).

38. *Picea engelmannii-Abies lasiocarpa-Pinus albicaulis-Pinus contorta* (04) v.t. at 2040 m on a steep southwest aspect in central Jasper (LC9181).

39. *Pseudotsuga menziesii/Juniperus* spp./*Arctostaphylos uva-ursi* (05) v.t. at 1410 m in southern Banff.

41. *Picea engelmannii-Abies lasiocarpa/Valeriana sitchensis-Erigeron peregrinus* (09) v.t. at 2000 m in northern Jasper (PA9078). This stand also contains much *Lupinus nootkatensis*.



43. *Picea* spp./*Ledum groenlandicum/Tomenthypnum nitens* (011) v.t. at 1270 m near the east gate of Jasper (JD9021).

40. *Picea engelmanni-Abies lasiocarpa/Salix* spp./*Aulacomnium palustre* (06) v.t. at 1920 m in central Banff (PA7029).

42. *Picea engelmannii-Abies lasiocarpa/Phyllodoce glanduliflora-Cassiope mertensiana* (010) v.t. at 2100 m in northern Banff (PA8161).

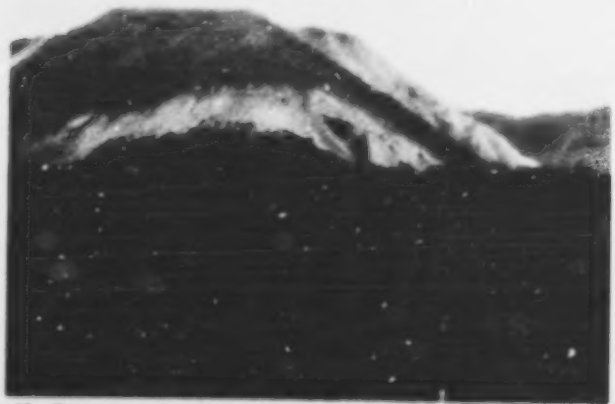
44. *Picea engelmannii-Abies lasiocarpa/Salix vestita/Arctostaphylos rubra* (012) v.t. at 2040 m in northern Banff (JC6102.2).

45. *Picea engelmannii-Abies lasiocarpa/ Salix vestita/ Pedicularis bracteosa* (014) v.t. at 2110 m in eastern Banff (JC8012.1).

46. *Betula papyrifera-Betula occidentalis / Arctostaphylos uva-ursi* (016) v.t. at 1200 m on a steep southwest aspect near the east gate of Jasper (IC7002).

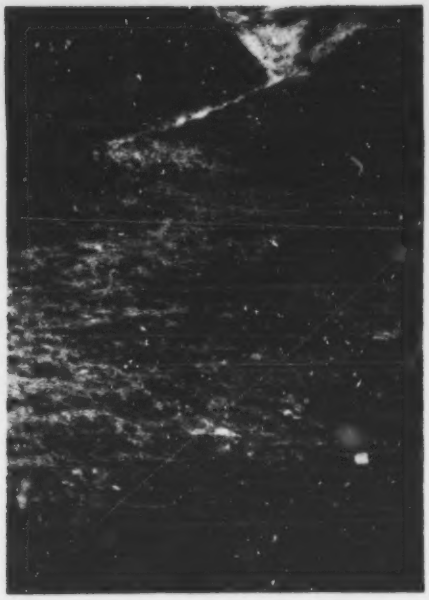
47. *Picea glauca/ Juniperus communis/ Arctostaphylos uva-ursi* (017) v.t. at 1780 m on a steep west aspect in northern Banff (JE8135).

48. *Picea engelmannii-Abies lasiocarpa/ Salix glauca/ Elymus innovatus* (018) v.t. at 2170 m in eastern Banff (PA7037).



49. *Picea engelmannii-Abies lasiocarpa/ Dryas octopetala* (019) v.t. at 2350 m in eastern Banff (PA8012.2).

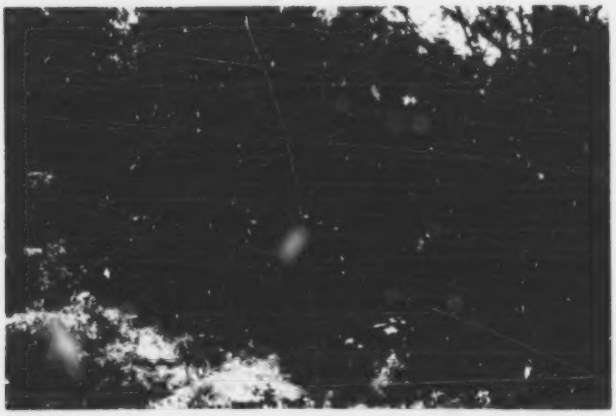
50. *Betula* spp.-*Potentilla fruticosa-Salix glauca/ Tomenthypnum nitens* (S1) v.t. at 1380 m in northern Jasper (PA9011).



51. *Abies lasiocarpa-Salix* spp./ *Valeriana sitchensis* (S2) v.t. in central Banff.

54. *Salix scouleriana-Alnus crispa/ Mertensia paniculata* (S6) v.t. at 1380 m in central Jasper (IC5019).

52. *Betula glandulosa-Potentilla fruticosa/ Scirpus caespitosus/ Drepanocladus revolvens* (S3) v.t. in northern Banff.



55. *Salix* spp./ *Equisetum arvense* (S7) v.t. at 1000 m in central Jasper (SJ8105).

53. *Salix* spp.-*Betula glandulosa/ Erigeron peregrinus* (S4) v.t. at 2100 m in central Jasper (IC5061).

56. *Salix barrattiana/ Potentilla diversifolia* (S8) v.t. at 2300 m in northern Banff (PA7133).

57. *Betula glandulosa-Salix glauca/ Kobresia myosuroides* (S9) v.t. at 1850 m in southeast Jasper (PA9117).

58. *Salix glauca-Betula glandulosa-Potentilla fruticosa* (S10) v.t. at 2040 m on a steep southwest aspect in central Banff (PA7152.1).

59. *Salix glauca/ Danthonia intermedia* (S11) v.t. at 2100 m in central Banff (PA7172).

60. *Salix glauca/ Elymus innovatus* (S12) v.t. at 2080 m in northeast Banff (JC8076).

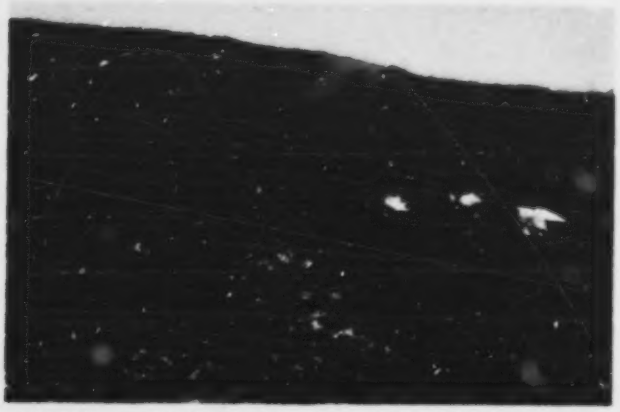
61. *Potentilla fruticosa/ Arctostaphylos uva-ursi-Galium boreale* (L1) v.t. in eastern Banff.

62. *Juniperus communis/ Salix glauca* (L2) v.t. at 2050 m on a steep southwest aspect in northern Jasper (PA9095).

63. *Cassiope tetragona/ Dryas octopetala-Salix nivalis* (L4) v.t. at 2360 m in eastern Banff (JD7008).

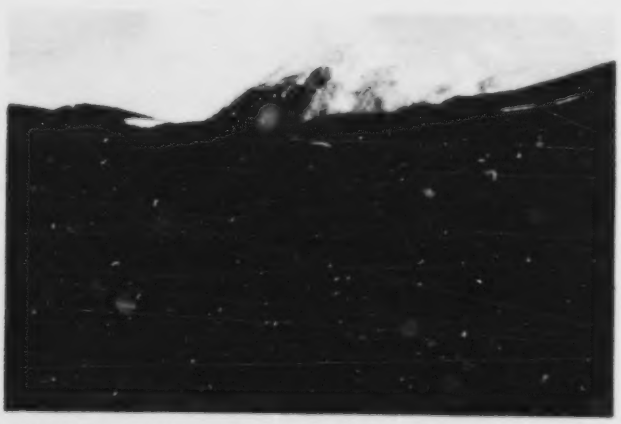
64. *Phyllodoce glanduliflora-Cassiope mertensiana/ Antennaria lanata* (L5) v.t. at 2240 m in western Jasper (SJ7076).

65. *Juniperus horizontalis/ Agropyron dasystachyum-Carex scirpoidea* (L6) v.t. near Talbot Lake in Jasper.



66. *Salix arctica/ Potentilla diversifolia* (L7) v.t. at 2260 m in northern Jasper (JD9070).

67. *Dryas octopetala-Salix nivalis-Silene acaulis* (H1) v.t. at 2340 m in eastern Banff (JD7009).



68. *Carex nigricans-Antennaria lanata* (H2) v.t. in southern Jasper.

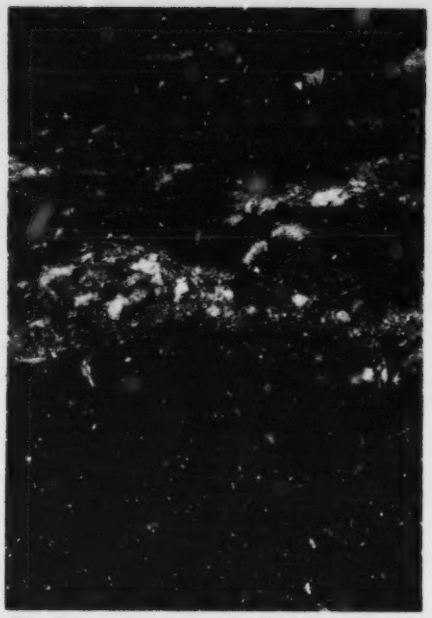
69. *Carex scirpoidea-Saxifraga aizoides* (H3) v.t. in central Banff.

71. *Elymus innovatus-Fragaria virginiana-Epilobium angustifolium* (H5) v.t. at 1890 m on a steep southwest aspect in northern Banff (1C7030).

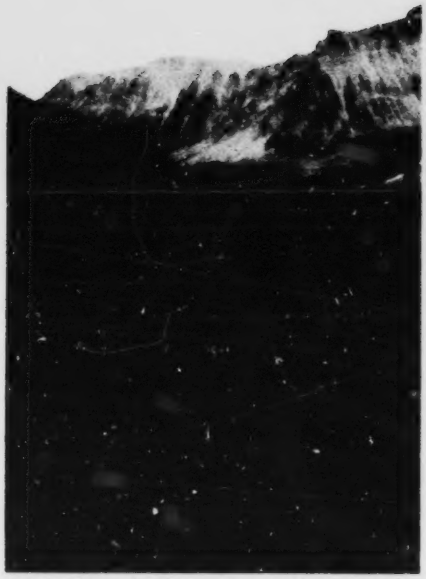
72. *Koeleria cristata-Artemisia frigida-Linum lewisii* (H6) v.t. at 1070 m in central Jasper (1C5003).

70. *Dryas octopetala-Kobresia myosuroides-Arctostaphylos uva-ursi* (H4) v.t. at 2330 m in western Jasper (1C6122).

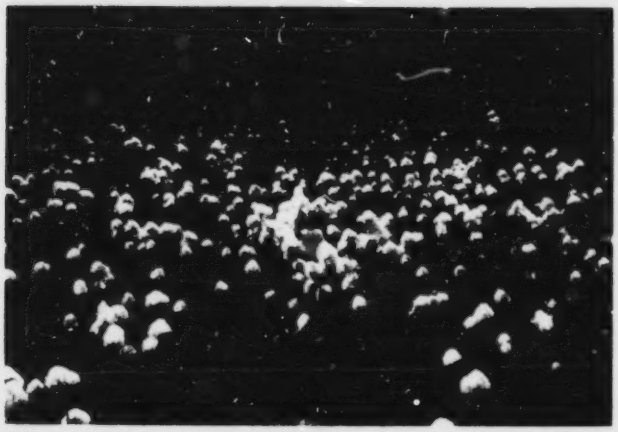
73. *Agropyron dasystachyum-Artemisia frigida* (H7) v.t. at 1140 m in central Jasper (1C5018).



74. *Dryas drummondii-Epilobium latifolium* (H8) v.t. at 1800 m in western Jasper (iC6067.3).



75. *Caltha leptosepala-Trollius albiflorus* (H9) v.t. at 2150 m in central Jasper (JC7053).



76. *Eriophorum angustifolium/ Drepanooladus revolvens* (H10) v.t. at 2320 m in northern Banff (PA8080).

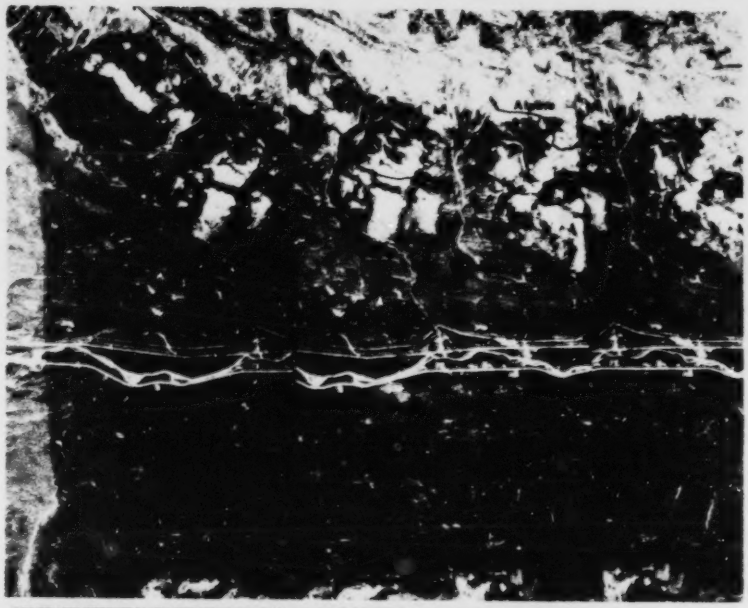
77. *Carex aquatilis-Carex rostrata* (H11) v.t. at 1380 m in central Banff (vicinity KS6054).

78. *Saxicolous lichen* (H12) v.t. at 2630 m in central Banff (PA7021).

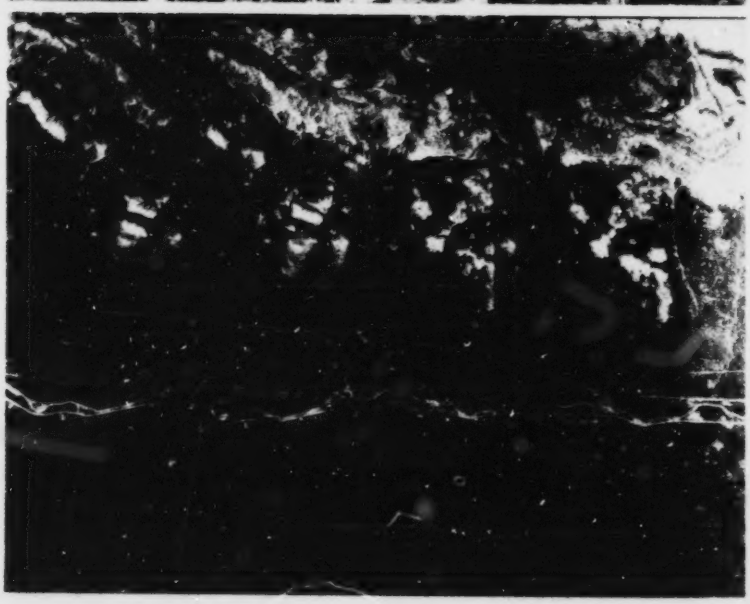
79. *Stipa richardsonii-Koeleria cristata-Antennaria nitida* (H13) v.t. at 1410 m in southern Banff (PA8000.2).

80. *Elymus innovatus-Koeleria cristata-Arctostaphylos uva-ursi* (H14) v.t. at 2380 m on a steep southeast aspect in eastern Banff (PA8012).

81. *Erigeron peregrinus-Valeriana sitchensis* (H16) v.t. in western Jasper.

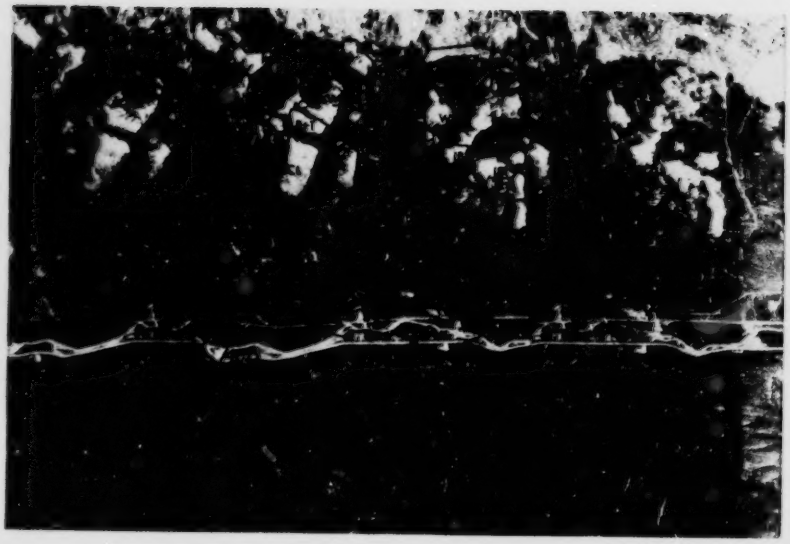


82. Stereo-triplet of the Bow River valley at Baker Creek showing landscape stratification of Ecoregions and Ecoregion subunits.

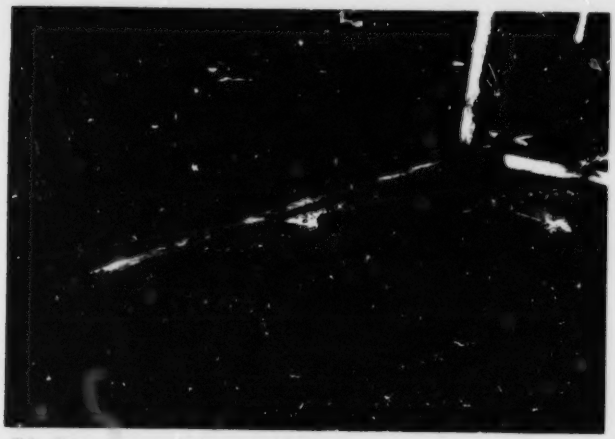


83. Stereo-triplet of the Bow River valley at Baker Creek showing landscape stratification of genetic material units.

85. *Pinus contorta/Shepherdia canadensis/Linnaea borealis* (C19) v.t. on Altrude 1 Ecosite (AL1).

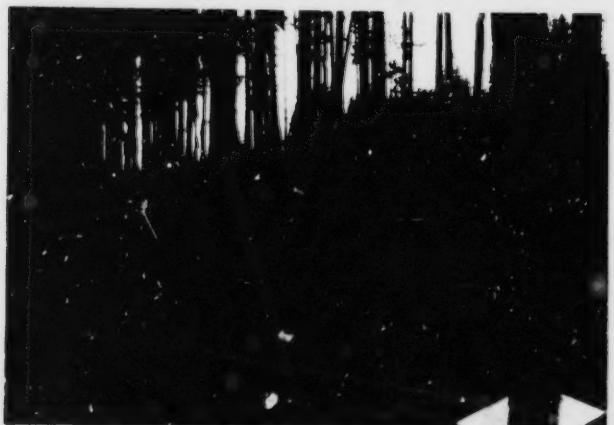


84. Stereo-triplet of the Bow River valley at Baker Creek showing detail of landscape stratification into Ecosite units.

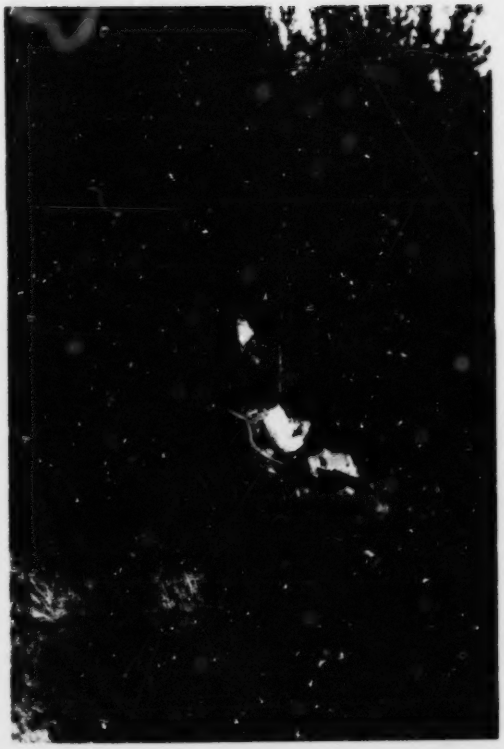


86. *Picea engelmannii-Abies lasiocarpa/Hylocomium splendens* (C13) v.t. on Altrude 2 Ecosite (AL2).

87. Complex slopes producing the dry-wet drainage pattern of the AZ1 Ecosite.

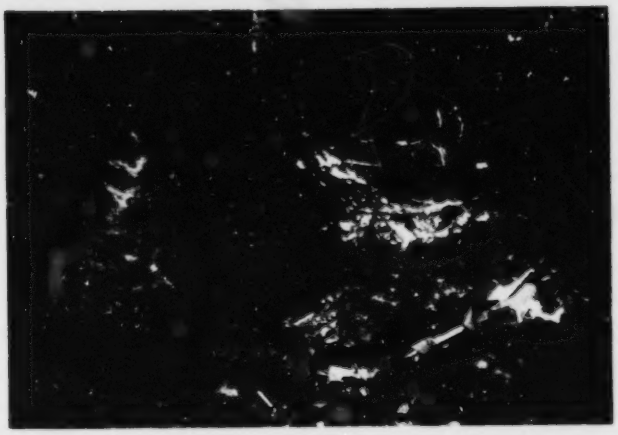


88. BK1 sample site showing a *Pinus contorta/Shepherdia canadensis/Vaccinium scoparium* (C18) v.t. stand of dry upland segments; described in Tables 112 and 114.



89. BK4 dry upland segment pedon site described in Table 116.

90. West depressional segment common on BK Ecosites showing shrub thicket vegetation.

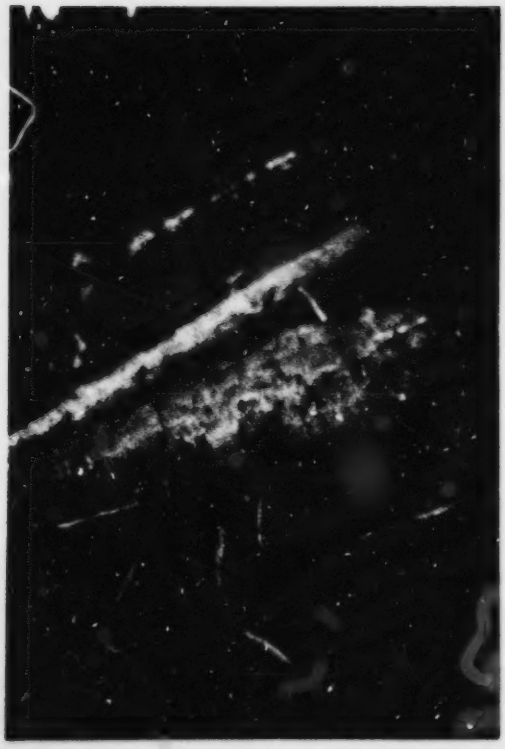


92. BP2 sample site showing a *Larix lyallii-Abies lasiocarpa/Vaccinium scoparium-Antennaria lanata* (C23) v.t. stand.

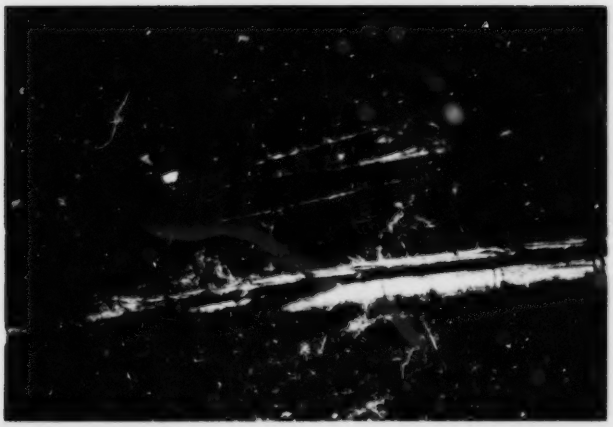
91. BP1 sample site showing landform and a *Picea engelmannii-Abies lasiocarpa-Pinus albicaulis-Pinus contorta* (04) v.t. stand.

93. BS1 landscape at Pipestone Pass in Banff.

94. BV1 sample site showing a *Pinus contorta/ Shepherdia canadensis/ Linnaea borealis* (C19) v.t. stand.

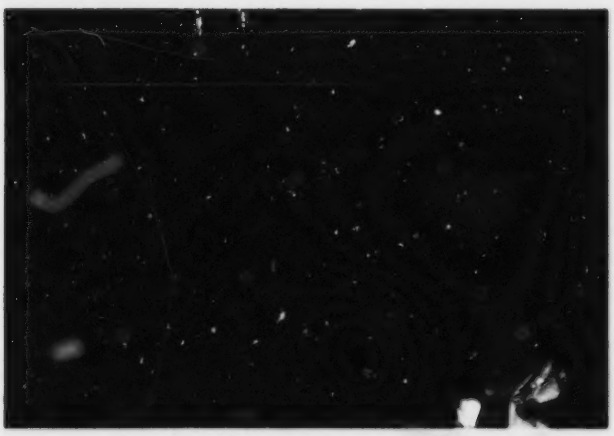


96. BY4 pedon sample site.

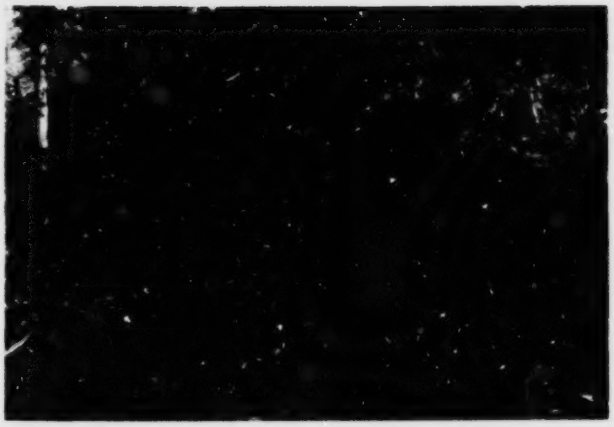


95. BY2 sample site showing a *Picea engelmannii-Abies lasiocarpa/ Elymus innovatus-Arnica cordifolia-Linnaea borealis/ Hylocomium splendens* (C31) v.t. stand.

97. BZ2 sample site showing a *Pinus contorta/ Ledum groenlandicum* (C29) v.t. stand.



98. CA1 wet segment pedon sample site.



99. CP1 sample site showing a *Picea engelmannii-Abies lasiocarpa/Vaccinium scoparium* (C15) v.t. stand.

100. CV1 wet segment pedon sample site.

101. Active Eolian material A in the Athabasca River valley in Jasper.

102. DV1 landscape.

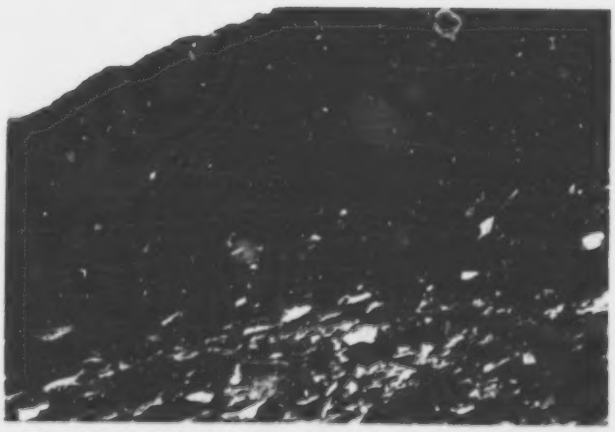
103. Blowout area on DV1 near Jasper Lake.

104. EF1 landscape with typically stony surface.

105. Landscape of EG1 and EG2 (background) and SX1 (foreground) in Lost Horse Creek, Banff.

106. EG2 sample site showing an open variant of a *Larix lyallii-Abies lasiocarpa/Vaccinium scoparium-Antennaria lanata* (C23) v.t. stand.

107. EN1 sample site showing a *Picea engelmannii-Abies lasiocarpa/Vaccinium scoparium* (C15) v.t. stand.



108. EN2 sample site showing an *Abies lasiocarpa-Salix* spp./*Valeriana sitchensis (S2) v.t. stand.*

109. EN3 sample site showing a *Picea engelmannii-Abies lasiocarpa-Pinus albicaulis-Pinus contorta* (04) v.t. stand.

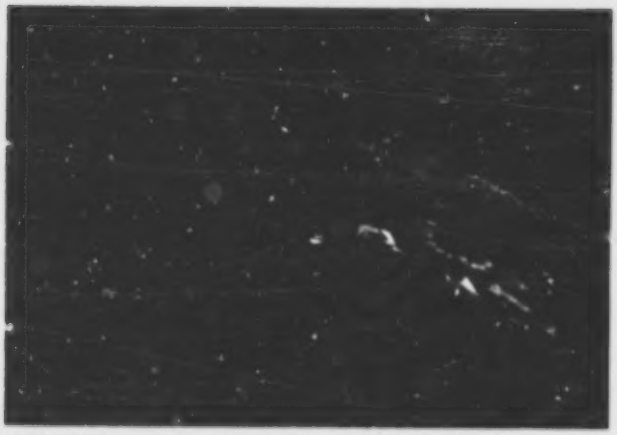
110. FR1 sample site showing a *Pinus contorta/ Shepherdia canadensis/ Aster conspicuus* (C6) v.t. stand.

111. FV1 sample site showing and *Abies lasiocarpa-Salix* spp./ *Valeriana sitchensis* (S2) v.t. stand.

112. FV2 sample site showing a *Picea engelmannii-Abies lasiocarpa/ Hylocomium splendens* (C13) v.t. stand.

113. GA1 landscape in Jasper.

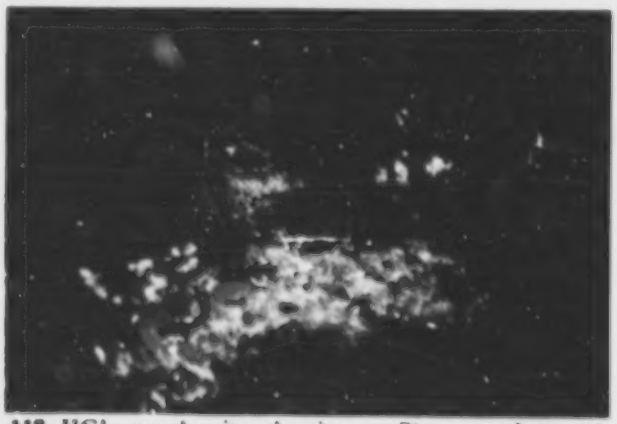
114. GT1 sample site showing an open variant of a *Pinus contorta/ Juniperus communis/ Arctostaphylo s uva-ursi* (C3) v.t. stand.



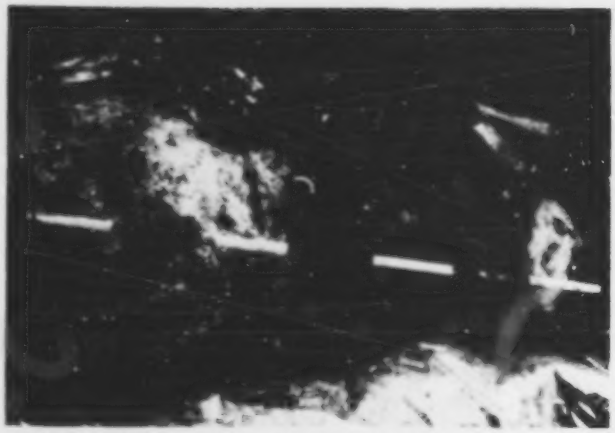
115. GT2 sample site showing a *Potentilla fruticosa/ Arctostaphylos uva-ursi-Galium boreale* (L1) v.t. stand of southerly aspect segments.

116. HC2 in a valley floor landscape between Mistaya and Upper Waterfowl Lakes in Banff.

117. HC4 in the valley bottom of the upper Spray River in Banff.



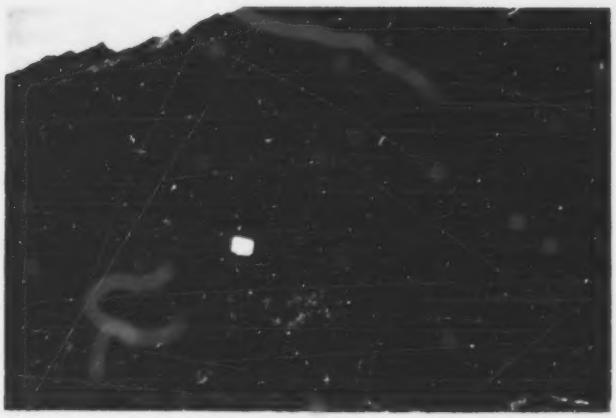
118. HC1 sample site showing a *Picea engelmannii/ Equisetum arvense/ Hylocomium splendens* (C32) v.t. stand.



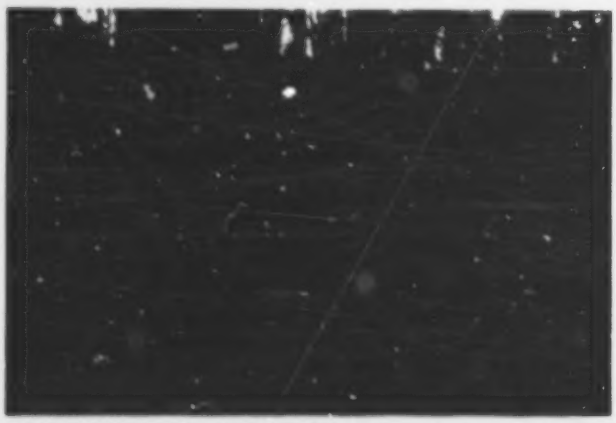
119. Sampled Rego Gleysol of the HC2 Ecosite.

120. HC2 pedon sample site.

121. HC2 pedon sample site showing a *Carex aquatilis-C.rostrata* (H11) v.t. stand.



122. HC4 sample site (Terric Mesisol) showing a *Betula glandulosa-Potentilla fruticosa/Scirpus caespitosus/Drepanocladus revolvens* (S3) v.t. stand.

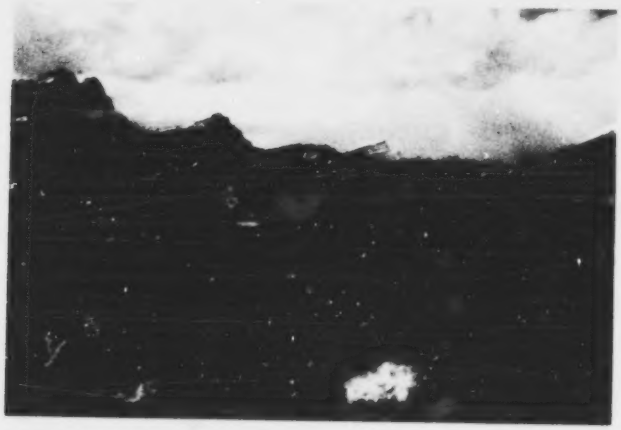


123. HD1 sample site showing a *Populus tremuloides/Elymus innovatus-Lathyrus ochroleucus* (C16) v.t. stand.

124. HD3 sample site showing a *Picea glauca-Pseudosuga menziesii/Hylocomium splendens* (C5) v.t. stand.

125. HD4 sample site showing a *Koeleria cristata-Artemisia frigida-Linum lewisii* (H6) v.t. stand.

126. HE1 landscape on the De Smet Range in Jasper.

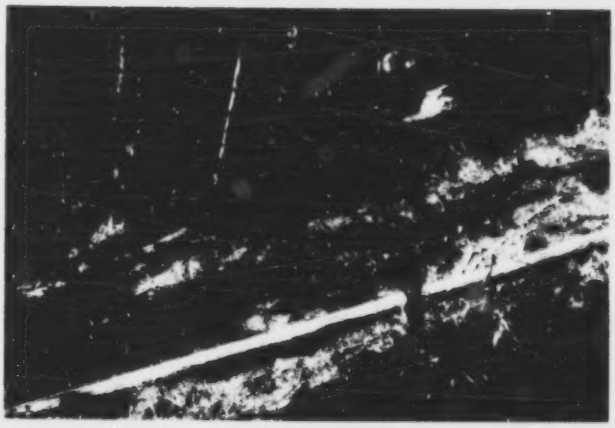


127. HE1 pedon sample site.

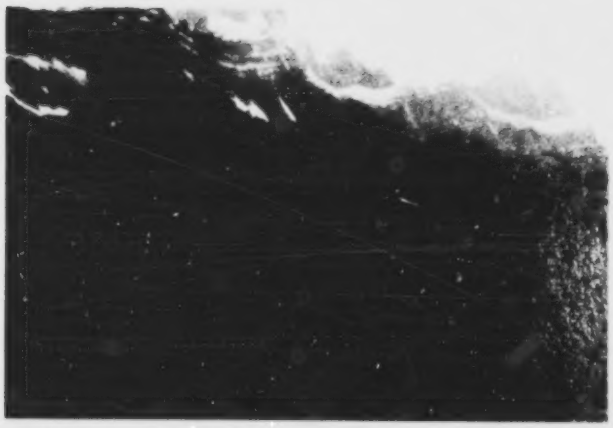
128. HE2 in the landscape (lower foreground) in a hanging cirque above Rockbound Lake in Banff.

129. Landscape near the HE2 sample site.

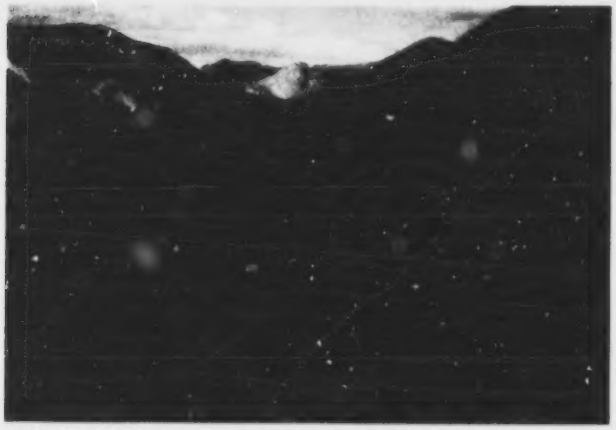
130. Ground level view of part of the HE2 tract in Plate 128 showing how soil and water affect vegetation in HE2.



131. IB1 sample site showing a *Pinus contorta/ Shepherdia canadensis/ Vaccinium scoparium* (C18) v.t. stand.



132. JN1 pedon sample site.



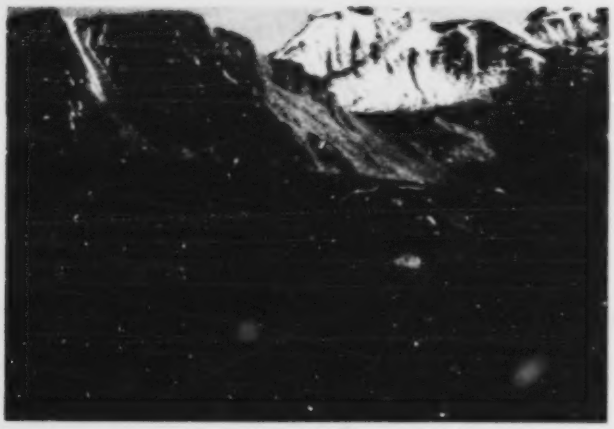
133. KA1 sample site showing a *Salix arctica-Potentilla diversifolia* (L7) v.t. stand.

134. LV1 sample site showing a *Larix lyallii-Abies lasiocarpa/ Vaccinium scoparium-Antennaria lanata* (C23) v.t. stand.

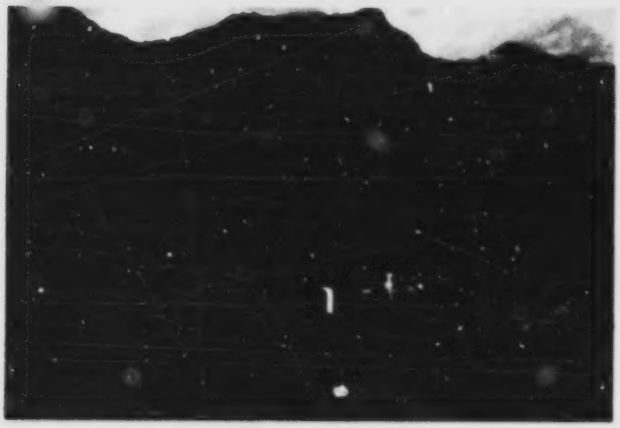
135. LV2 sample site showing the *Phyllodoce glanduliflora-Cassiope mertensiana-Antennaria lanata* (L5) and *Picea engelmannii-Abies lasiocarpa/ Phyllodoce glanduliflora-Cassiope mertensiana* (010) pattern of v.t.s typical on LV2.

136. MC1 wet depressional segment pedon sample site.

137. Severely soliflucted and cryoturbated MP1F tract.



138. A soliflucted MP1 tract with little surface manifestation of solifluction.



139. MP1 sample site showing a *Dryas octopetala-Salix nivalis-Silene acaulis* (H1) v.t. stand.

140. NT2 pedon sample site.

141. NT3 sample site showing a *Carex aquatilis-C. rostrata* (H11) v.t. stand.

142. NY3 northerly aspect segment sample site showing a *Picea glauca-Pseudotsuga menziesii/Hylocomium splendens* (C5) v.t. stand.

143. PL3 sample site showing a *Larix lyallii-Abies lasiocarpa/Vaccinium scoparium-Antennaria lanata* (C23) v.t. stand.

144. PL4 sample site showing a *Picea engelmannii-Abies lasiocarpa/Phyllodoce glanduliflora-Cassiope mertensiana* (010) v.t. stand.

145. PL5 wet depression segment sample site showing a *Salix glauca/Danthonia intermedia* (S11) v.t. stand.

146. PP3 sample site showing *Picea engelmannii-Abies lasiocarpa/Hylocomium splendens* (C13) v.t. stand.

147. PP4 sample site showing a *Dryas drummondii-Epilobium latifolium* (H8) v.t. stand.

148. PP6 sample site showing a *Picea engelmannii-Abies lasiocarpa/Salix glauca/Elymus innovatus* (018) v.t. stand.

149. PR2 pedon sample site.

150. PR3 pedon sample site showing a *Pinus contorta/ Shepherdia canadensis/ Vaccinium scoparium* (C18) v.t. stand.

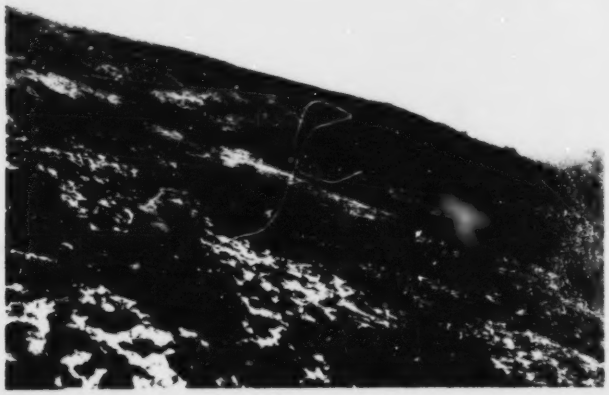
151. PR4 southerly aspect segment sample site showing a *Pinus contorta/ Juniperus communis/ Arctostaphylos uva-ursi* (C3) v.t. stand.

152. PR6 pedon sample site showing a *Pinus contorta/ Hylocomium splendens* (C11) v.t. stand.

153. PT3 sample site showing a *Pinus contorta/ Juniperus communis/ Arctostaphylos uva-ursi* (C3) v.t. stand.

154. Sampled stand of the *Populus tremuloides/ Elymus innovatus-Lathyrus ochroleucus* (C16) v.t. on PT4.

156. SB1 sample site showing a *Populus tremuloides/ Elymus innovatus-Aster conspicuus* (C22) v.t. stand.



155. RD1 pedon sample site showing a *Salix arctica-Potentilla diversifolia* (L7) v.t. stand.

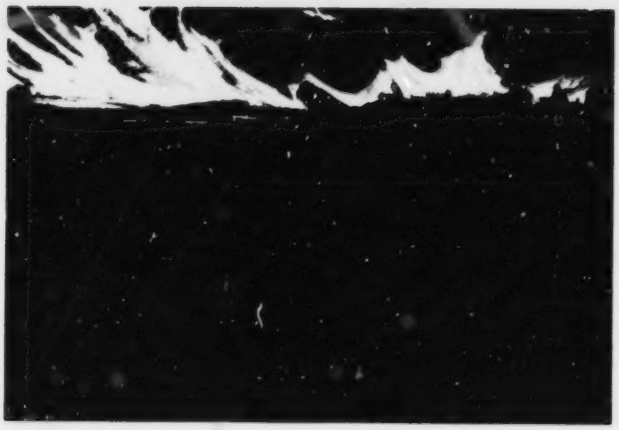
157. SB3 sample site showing a *Pinus contorta/ Shepherdia canadensis/ Aster conspicuus* (C6) v.t. stand.

158. SB4 sample site showing an open variant of a *Pinus contorta/ Juniperus communis/ Arctostaphylos uva-ursi* (C3) v.t. stand.

159. SB5 sample site showing an *Elymus innovatus-Koeleria cristata-Arctostaphylos uva-ursi* (H14) v.t. stand.

160. SF1 in a landscape near Mount Sassenach in Jasper.

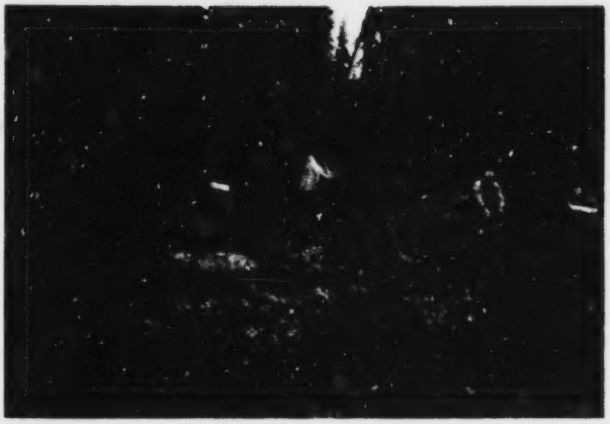
161. The influence of aspect on the distribution of Ecosites in Front Ranges areas underlain by Mesozoic strata.



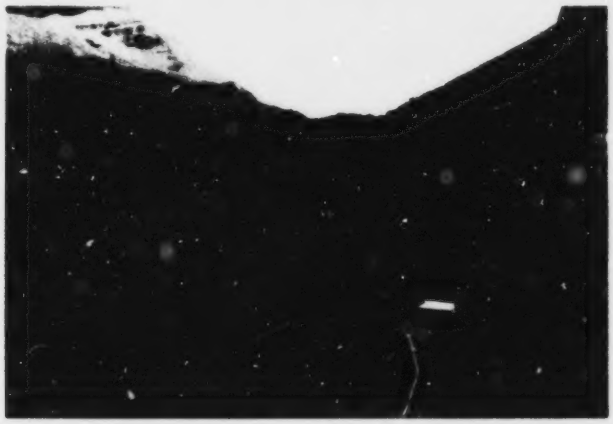
162. Unconfined surface flow from spring snow melt on a SX1 tract.

163. Herb dominated SX1 and forested SX2 in the Miette (Centre) Pass area of Jasper.

164. SX1 sample site showing an *Erigeron peregrinus-Valeriana sitchensis* (H16) v.t. stand.



165. SX2 sample site showing a *Picea engelmannii-Abies lasiocarpa/Valeriana sitchensis-Erigeron peregrinus* (09) v.t. stand.



166. SX3 pedon sample site showing a *Betula* spp.-*Potentilla fruticosa/Salix glauca/Tomenthypnum nitens* (S1) v.t. stand.

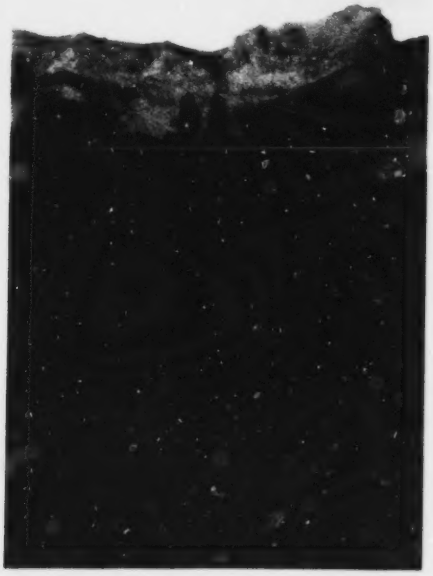
167. TA2 in a landscape near Moosehorn Creek in Jasper.

168. TA2 sample site showing a *Koeleria cristata-Artemisia frigida-Linum lewisii* (H6) v.t. stand.

169. TA3 sample site showing a *Picea glauca/Rosa acicularis/Thuidium abietinum* (C27) v.t. stand.

170. TK1 sample site showing a *Dryas octopetala-Salix nivalis-Silene acaulis* (H1) v.t. stand.

171. TR1 in a landscape near Arcturus Peak in Jasper.



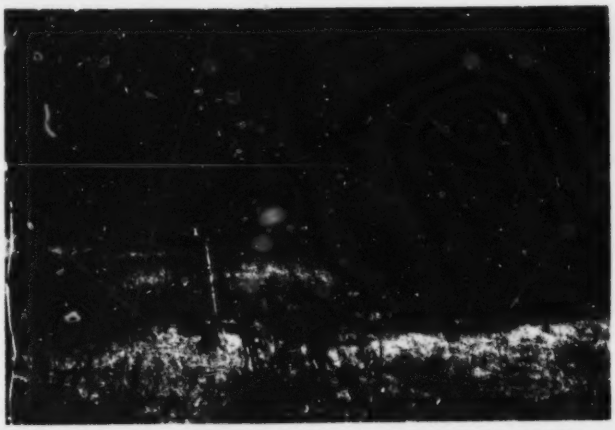
172. Fire boundary (left centre) demarcating a shrub dominated TR1 tract from the forested SF1 tract.

173. TR1 sample site showing a *Salix glauca-Betula glandulosa-Potentilla fruticosa* (S10) v.t. stand.

174. TR2 sample site showing a *Dryas octopetala-Kobresia myosuroides-Arctostaphylos uva-ursi* (H4) v.t. stand.

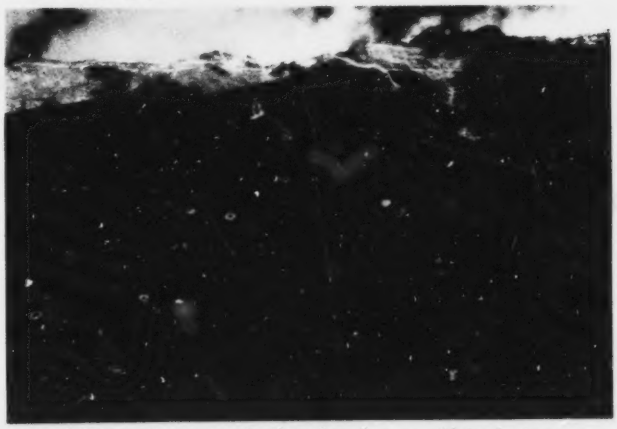
175. TZ2 dry upland segment sample site showing a *Pinus contorta-(Picea engelmannii)/ Empetrum nigrum/ Cladonia mitis* (C35) v.t. stand.

176. VL1 and VL3 in a valley floor landscape near Banff townsite.

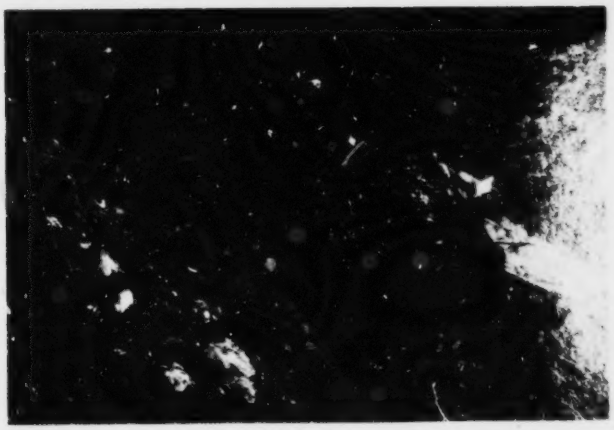


177. VL3 pedon sample site showing a *Picea glauca/ Rosa acicularis/ Equisetum arvense* (C4) v.t. stand.

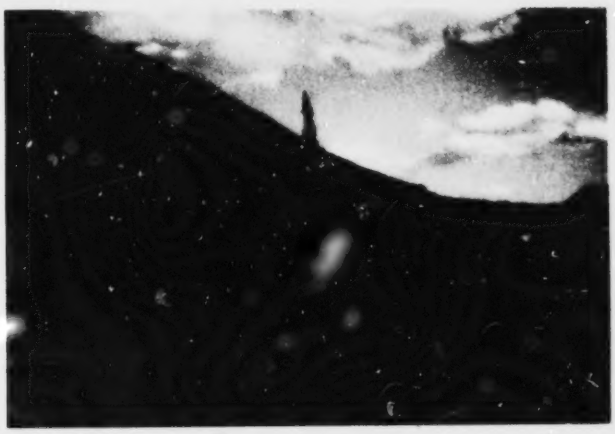
178. WF1 sample site showing a *Picea engelmannii-Abies lasiocarpa/ Vaccinium membranaecum/ Barbilophozia lycopodioides* (C21) v.t. stand.



179. WF2 pedon sample site showing an *Abies lasiocarpa-Salix* spp./ *Valeriana sitchensis* (S2) v.t. stand.



180. WF4 sample site showing a *Picea engelmannii-Elymus innovatus* (C33) v.t. stand.

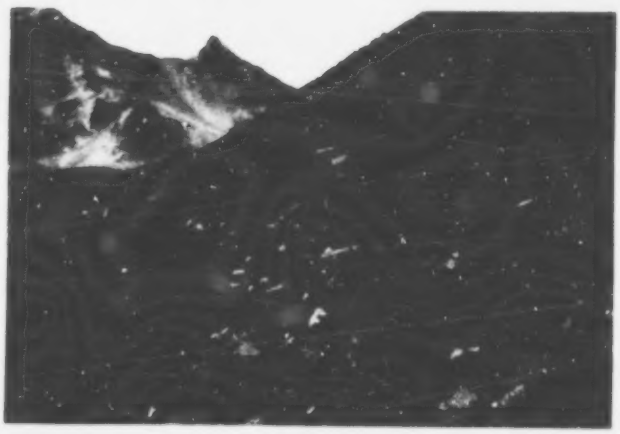


181. WF7 sample site showing the *Elymus innovatus-Koeleria cristata-Arctostaphylos uva-ursi* (H14) v.t. stand.

182. WH1 sample site showing a *Larix lyallii-Abies lasiocarpa/ Vaccinium scoparium-Antennaria lanata* (C23) v.t. stand.

183. WH3 in a landscape near Miette Pass in Jasper.

186. WW1 sample site showing a *Dryas drummondii-Epilobium latifolium* (H8) v.t. stand.



184. WH3 landscape near Whitehorn mountain in Banff showing an *Abies lasiocarpa-Salix* spp./*Valeriana sitchensis* (S2) v.t. stand.

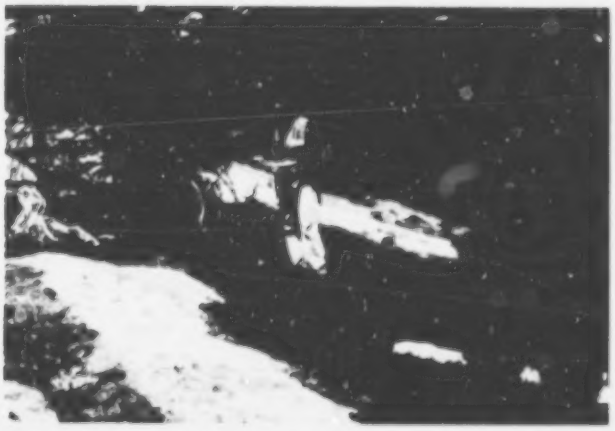
185. WH5 sample site showing a *Saxifraga bronchialis-Elymus innovatus* (H20) v.t. stand.

187. Snow avalanche paths modifying a BY Ecosite (BY1A) in Arctomys Creek Valley in Banff.

188. Fire modified PR4 tract (PR4B) near Vermilion Pass in Banff.

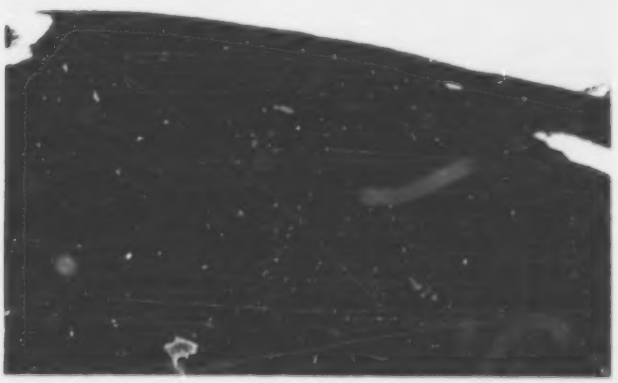
189. Fire modified PL1 and PL3 tracts (PL1B, PL3B) on Cascade Mountain in Banff.

190. Failing slope on the WF7 tract (WF7F) in the Tyrrell Creek valley in Banff.



191. PL4 tract dominated by lithic soils (PL4X) in the Sunset Pass area of Banff.

192. A Colluvial Landslide (CL) above Baker Creek in Banff.



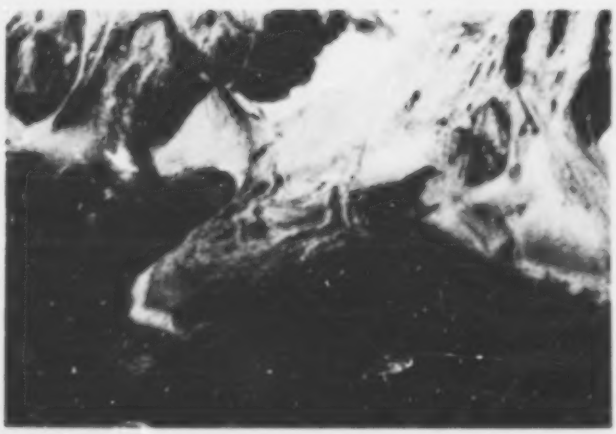
193. A Colluvial Rubble (CR) landscape near Tangle Ridge in Jasper.

194. Glacier (GL) in a landscape on Mount Wilson in Banff.

195. Recent Moraine (M) in a landscape on Mount Strahan in Banff.

196. Mapped complex of Rockland and Glacier (R + GL) in a landscape near Bush Pass in Banff.

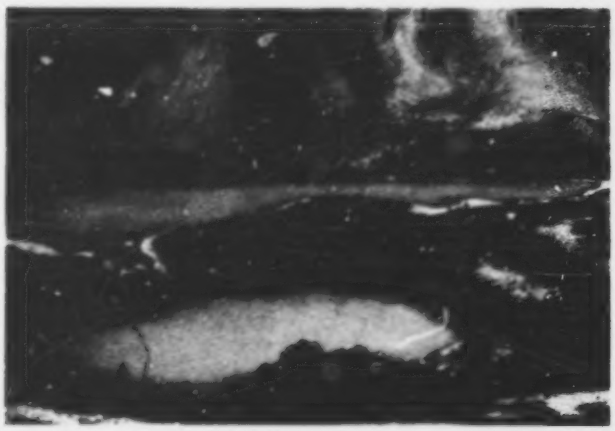
197. Typical Rockland (R).



198. Rock Glacier (RG) in a landscape near Miette (South) Pass in Jasper.

199. Stream channel (SC) in a landscape on the Sunwapta River in Jasper.

200. Talus (T) cones coalescing around the base of Mount Warwick in Jasper.



201. Water Bodies (blue on map) above Roaring Creek in Banff.

Volume

3

Environment Canada
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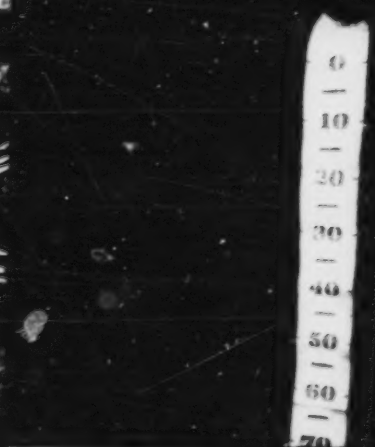
Ecological (Biophysical) Land Classification Of Banff and Jasper National Parks

Vol. III: The Wildlife Inventory

By Geoffrey J. Holroyd and Kevin J. Van Tighem



Canada

The Ecological (Biophysical) Land Classification

of

Banff and Jasper National Parks

Volume III **THE WILDLIFE INVENTORY**

Geoffrey L. Holroyd

and

Kevin J. Van Tighem

Produced by

Canadian Wildlife Service, Edmonton

for

Parks Canada, Western Region

Environment Canada | Environnement Canada
Canadian Wildlife Service | Service canadien de la faune

Your file | Votre dossier
Our file | Notre dossier

1000, 9942 - 108 Street
Edmonton, Alberta
T5K 2J5

March 31, 1983

Mr. S. Kun
Director, Western Region
Parks Canada
520, 220 - 4th Avenue, S.E.
Calgary, Alberta
T2P 3H8

Dear Mr. Kun:

I submit herewith a report entitled: "Ecological (Biophysical) Land Classification of Banff and Jasper National Parks, Volume III The Wildlife Inventory", by Geoffrey L. Holroyd and Kevin J. Van Tighem. This extensive document describes the wildlife and their habitats of the two parks in great detail as well as integrating wildlife habitat with the Land Classification Legend. Other integrated wildlife data is presented as part of Volume I and the Map Supplement which are part of this series of reports produced in cooperation with the Canadian Forestry Service.

This nine year project was done as part of the Canadian Wildlife Service Parks Research activity in close cooperation with the Canadian Forestry Service, Alberta Institute of Pedology and Agriculture Canada. This multi-agency effort has resulted in an Ecological Inventory that will serve Parks Canada for many years. This cooperative approach greatly increases productivity and effectiveness of our department.

Yours sincerely

George Kerr

A/ Gordon R. Kerr
Regional Director

Part A

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1. INTRODUCTION

The Banff-Jasper ecological (biophysical) land classification was developed between 1974 and 1981. It is based on an integrated resource inventory in which all resource components (geological parent material, landform, soil, vegetation and wildlife) are dealt with together in a common land classification scheme and at a common 1:50,000 mapping scale.

The land inventory was conducted by scientists of the Canadian Forestry Service and the Alberta Institute of Pedology. Mainly soil scientists and botanists, this team collected data on landforms, soils and vegatation, developed the basic classification scheme and produced the ecological (biophysical) maps of the Map Supplement that accompanies this report.

The wildlife inventory was conducted by biologists of the Canadian Wildlife Service, working in close liaison with the land inventory team. The wildlife inventory team collected a variety of data on the distribution and abundance of wildlife in the two parks, particularly with regard to wildlife use of ecosites, the basic unit of the ecological land classification.

The **Map Supplement** which accompanies this final report delineates the distribution of ecosites in Banff and Jasper on 22 maps at a scale of 1:50,000 and includes a Map Legend which summarizes the characteristics of each ecosite.

Volume I consists of an abbreviated summary of the methods and results of both teams.

Volume II consists of the detailed report of the land inventory team. Ecosites, vegetation types and various aspects of the parks' physical environment are described in detail here, as is the ecological classification system. Volume II is essential to a full understanding of concepts discussed in this volume.

This volume, **Volume III**, is the detailed report of the wildlife inventory team. Its composition is described further in the Users' Guide, below. The report was written by a number of members of the wildlife team and entirely editted or re-written by G. Holroyd, project leader, and K. Van Tighem. First draft authors are:

Author	Sections:
Gordon Burns	2(in part), 3.3(small mammals), 5.2(in part), 6(in part).
Geoff Holroyd	1.1, 1.2, 2(in part), 3.3(in part), 4.3, 5.1, 5.2, 6.1, 8(in part).
John Kansas	3.3(carnivores), 4.2.1, 4.2.2.
Rhonda Markel	2(in part), 3.1, 3.3(in part)
Keith McDougall	1.3, 3.3(in part), 4.2.3, 7(in part).
Margaret Skeel	3.2(in part), 4.1(in part), 5.1(in part).
Kevin Van Tighem	1.3(in part), 3.2(in part), 3.3(in part), 4.1(in part), 4.2.4, 6.2, 7, 8(in part).

Over the years many people became members of the wildlife inventory team only to move on before the inventory was completed. All provided major contributions to the data base and several, through working on interim reports, ultimately contributed to this final report. Inventory staff are acknowledged above.

1.1. USERS' GUIDE TO VOLUME III

This volume will be read by a wide variety of readers. Your interests will vary, but each will be seeking some kind of information on wildlife. We anticipate that your interest will be in one or more of four major areas: certain wildlife species, their habitats, their distribution by ecosite and geographic areas used by wildlife.

If you are interested in information on certain species, your first stop is the species accounts (section 3). Here each species is discussed under the headings

* Status and distribution
* Habitat
* Life History
* Management Considerations

If you are interested in an ungulate species you should also review the section on ungulate surveys (section 4.2). If you are interested in a bird species you should review the descriptions of breeding bird communities (section 5.1) and bird migration (section 4.1). Small mammal information will similarly be found in the descriptions of small mammal associations (section 5.2).

We anticipate that most other users of this volume will be interested in wildlife habitat and its distributiion, or in the use by wildlife of certain areas of land. These topics comprise the biophysical aspect of the inventory.

Wildlife habitat is discussed in general terms in each of the species accounts. However, much of the habitat data are incorporated in the various discussions of ecosites. If you are interested in a certain geographic area you should review the appropriate map in the Map Supplement that accompanies Volume I of this report. Locate your area of interest on the map and list the ecosite names that are indicated. To learn about the ecoregion, landform, soil, typical vegetation and other physical characteristics of these ecosites, read the Master Legend that accompanies the Map Supplement , or read the ecosite accounts in Volume II of this report.

Wildlife data for each ecosite are found in two places. The first is at the right side of the Master Legend where the Wildlife Legend provides a table of the relative importance of each ecosite to selected wildlife species and a list of which breeding bird communities and small mammal associations occur there. The second is the ecosite account section of this volume (section 6.1). There the importance of the ecosites to wildlife is discussed in somewhat more detail.

One further source of geographical information on wildlife is the watershed accounts (section 7). These describe the distribution of habitats and wildlife within various watersheds. Their purpose is to give an overview of wildlife distribution, and to identify specific areas of importance, where these cannot be presented within a discussion of a single ecosite.

All readers may be interested in the methods section (section 2) to see the means by which the above information was gathered. There is no section actually presenting uninterpreted results, due mainly to the great bulk of data and analysis involved. Plot and transect data and all wildlife observations are stored on the Canadian Soil Information System computer in Ottawa and are accessible through Parks Canada computers in Western Regional Office and the respective parks.

Recommendations are presented in many of the species accounts (under Management), in the watershed accounts, and in the recommendations section (section 8). The rest of this introduction will provide the reader with a general description of Banff and Jasper National Parks and a brief history of the interaction of man and wildlife and an account of wildlife management as it has evolved in these two national parks in the past century.

1.2. DESCRIPTION OF THE STUDY AREA

The geology, climate, soils and vegetation of Banff and Jasper National Parks are described in detail in Volume II. The following is a general description only, concentrating on aspects of the park environments having particular relevance in any discussion of wildlife.

Banff and Jasper extend along the east side of the Continental Divivde in the Rocky Mountains of western Alberta. The southern tip of Banff is at 50°42' N lat. and the northern tip of Jasper is at 53°29' N lat. The parks respectively contain 6644 km² and 10878 km² of mountainous terrain.

Banff National Park contains the headwaters of the Bow, Red Deer, Clearwater, and North Saskatchewan Rivers. These streams are all tributaries of the Saskatchewan River system. Jasper National Park contains the headwaters of the Brazeau, Athabasca and Smoky Rivers. The Brazeau is a tributary of the Saskatchewan system. The Athabasca flows east and then north to Lake Athabasca where it joins the Peace River, of which the Smoky is a tributary, and ultimately flows to the Arctic Ocean. Major watersheds are illustrated in Figures 1.1 and 1.2.

The Rocky Mountains are the eastern-most mountain chain of the North American Cordillera in Canada. Their valleys and ranges have a generally northwest-southeast alignment except where major valleys cut through the ranges in an easterly direction. There are two major divisions of the Rockies in Banff and Jasper.

The Main Ranges are the western-most mountains. These ranges are complex geologically, with considerable folding, faulting and uplift. They include the highest peaks and the most extensive icefields and glaciers in the Rockies. They receive up to three times as much precipitation and considerably less wind than do the mountains farther east (Janz and Storr 1977).

The Front Ranges are the eastern-most mountains. They are generally sloping along their westerly exposures and faced with steep cliffs and talus on their easterly exposures, being a series of tilted thrust blocks. Their peaks and valley bottoms are generally lower than the Main Ranges and they have fewer glaciers. Their climate is drier and windier than that of the Main Ranges, with a more pronounced continental influence.

Although the climate of Banff and Jasper is predominantly continental, with very cold winters and mild summers, and a summer peak in precipitation, the climate becomes more maritime-cordilleran at higher elevations. Above 1500 m, especially along the Main Ranges, precipitation peaks in winter and winter temperatures may be somewhat milder than in adjacent valley-bottoms.

In addition to an east-west variation in climate, then, Banff and Jasper show marked differences in climate from low elevations to high. Based on vegetation differences - since vegetation reflects climate to a great extent - the ecological land inventory recognizes three major ecoregions, the montane, the subalpine (further differentiated into lower and upper ecoregions), and the alpine.

The **montane** ecoregion is limited to the lowest elevations of Banff and Jasper, along the lower Bow, Cascade, North Saskatchewan, Athabasca, Miette and Snake Indian valleys. Except in the Miette and middle Athabasca valleys, it is confined to the Front Ranges. Climatically, it is characterized by low precipitation (less than 500 mm/yr), warm summers, and mild winters with frequent mild, westerly winds and intermittent snow cover. Vegetation reflects the dry local climate, with lodgepole pine forest, aspen and Douglas-fir stands, and dry grasslands. Some extensive wetland areas have developed along floodplains and are characterized by white spruce forest, willow stands and sedge meadows.

Figure 1.1. Banff National Park: major watersheds and mountain divisions.

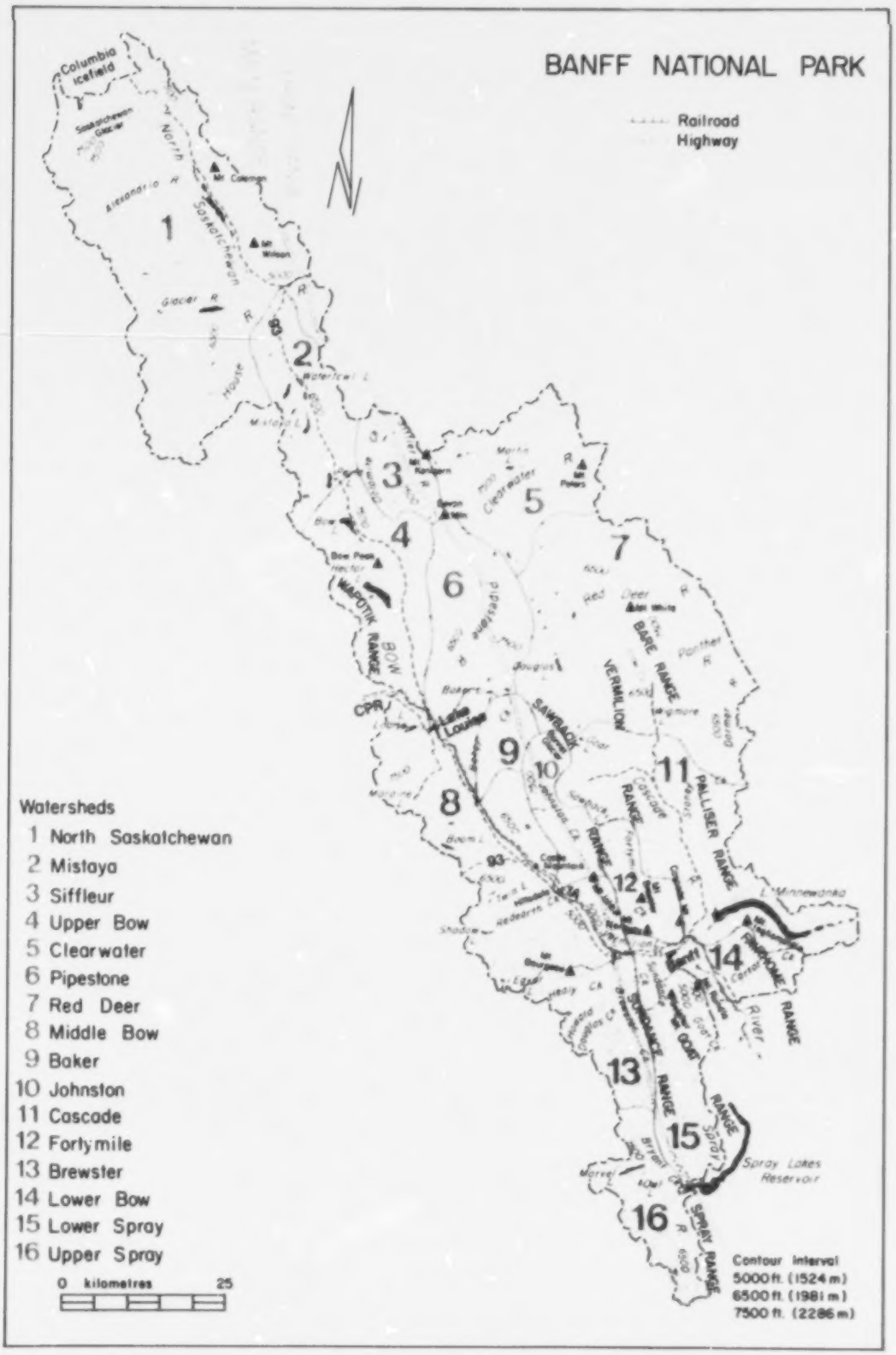
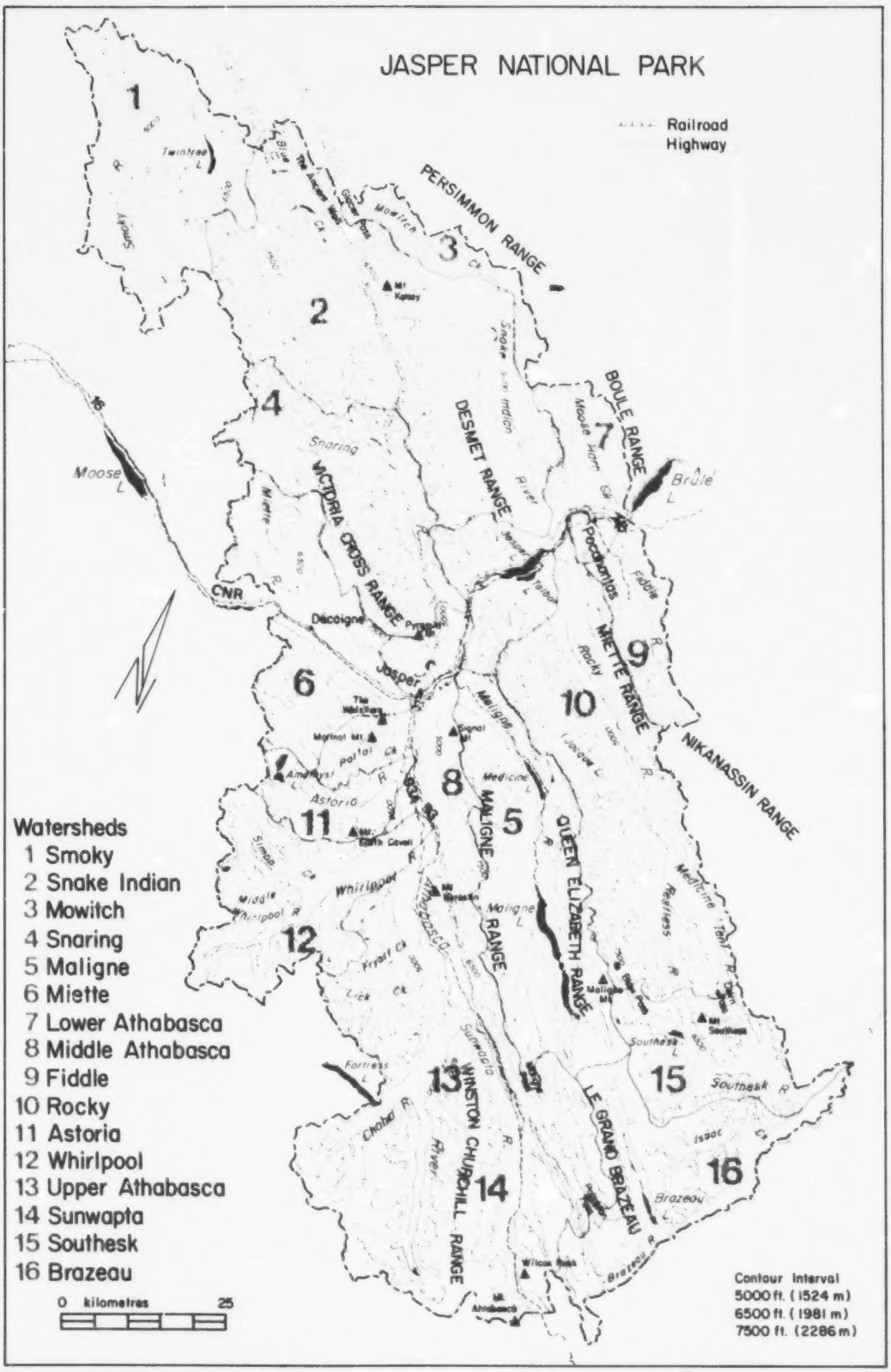


Figure 1.2. Jasper National Park: major watersheds and mountain divisions.



The **subalpine** ecoregion is very extensive and dominates most of the two parks, in both the Front and the Main Ranges. Precipitation is higher here (500-1250 mm/yr) and temperatures cooler than in the montane. Consequently, winter snow accumulation is greater and lasts longer. Since the subalpine ecoregion is at higher elevations than the montane ecoregion, well-developed floodplain complexes are less prevalent and wetlands are less productive, remaining frozen longer.

The lower subalpine ecoregion is characterized by extensive lodgepole pine forests and - where it has escaped burning in the last century and a half - by Engelmann spruce-subalpine fir forest. Climatically it is milder than the upper ecoregion, with less precipitation and milder winters. Snow accumulation is frequently shallow enough, especially in the Front Ranges, to allow ungulates to winter here. Periodic severe winters, however, cause die-offs of ungulates.

The upper subalpine ecoregion is characterized by open-canopied forests of Englemann spruce and subalpine fir, and locally of subalpine larch or whitebark pine. Timberline is the upper limit of this ecoregion. Snow accumulation is heavy and winters are too severe for ungulates except on steep, wind-blown slopes. Because of its heavy precipitation, however, this ecoregion constitutes a lush, productive summer habitat for many species of wildlife.

The subalpine ecoregion is further characterized by alluvial meadows where cold air pooling inhibits tree growth, maintaining open shrublands, and by wind-exposed slopes where dessication and drought inhibit trees.

The **alpine** ecoregion is the highest and coldest ecoregion. It receives heavier precipitation than any of the other ecoregions but much of this - since there are no trees to stop the wind - is redeposited at lower elevations. Tree growth is prevented by cold winters, cool summers and high winds, and the vegetation is a mosaic of low shrub and herb communities.

Within each of these ecoregions there is a variety of landforms, soils and vegetation that create a diverse habitat mosaic. Generalizations about wildlife distribution within any single ecoregion are confounded by the variablility of habitats within the ecoregion. Volume II describes this variabiiity and classifies the parks with regard to recurring patterns of landform, soils and vegetation within each ecoregion. This classification is the basis of discussions of wildlife habitat in subsequent sections of this volume.

1.3. WILDLIFE, MAN AND HABITAT: AN OVERVIEW 1800 - 1980

In 1754 Anthony Henday beheld the shining mountains from near the present site of Red Deer, Alberta. He was the first European to report the existence of the Rocky Mountains at the western edge of Canada's great plains. None would cross those mountains for another 46 years.

No event since the retreat of the Pleistocene glaciers has had so profound an impact on the land and wildlife in what are now known as Banff and Jasper National Parks as did the arrival of European man. Almost two centuries after the first white

explorer entered the mountains, the face of the land and the fate of its wildlife are irrevocably marked by the hand of man.

Man's earliest major impact was to hunt beaver, muskrat and carnivores for fur, and ungulates for food. Both by accident and by design he burned the forests. His depletion of wildlife by gun, trap and fire combined with natural events such as severe winters and disease to drastically alter the results of long centuries of gradual change.

The establishment of national parks at Banff in 1885 and Jasper in 1917 led to the protection of land and wildlife. Ungulates and carnivores increased again, re-colonizing areas that had been depleted in the 19th century. However, the West was developing and the national parks were becoming islands of intact habitat in a sea of lands committed to various resource uses and development pressures. Even within the parks the demand for facilities for park users came into conflict with the needs of wildlife, and wildlife occasionally came into conflict with man.

Thus, wildlife management evolved. At first access was limited, manpower was scarce and understanding of the natural processes influencing wildlife was scanty. Wildlife management consisted of shooting predators and arresting poachers. Over time, as wildlife populations, visitor use patterns and public awareness changed, wildlife management became increasingly complex. Ungulate range management, bear control, forest succession and other aspects of these mountain ecosystems have come to demand more detailed research and occasional manipulations of the environment. The potential for irreversible damage to wildlife and its environment through incautious development has likewise led to wildlife research and environment impact assessment procedures.

From pemmican to computer chip technology in two short centuries; the interactions among wildlife, man and environment have evolved dramatically in Banff and Jasper since the first fur traders. The following provides a brief overview of some of these changes.

1.3.1 WILDLIFE IN THE ROCKIES - PRE-HISTORIC TIMES (PRE-1850)

The Rocky Mountains have sustained wildlife for only the few thousand years since the retreat of the last great glaciers. During that time vegetation and wildlife have invaded the mountain valleys, influenced by a gradual sequence of climatic change and events such as fires, landslides and floods. When the first Europeans arrived in the Rockies two centuries ago they witnessed a young, dynamic landscape, an assemblage of plants and animals that was not only new but still evolving.

The youthfulness of the Rocky Mountain environment means that modern management directed at restoring or perpetuating "pristine" conditions would be somewhat unrealistic. It also renders difficult any attempt to reconstruct a picture of past wildlife conditions. The environment has always been dynamic; always changing and adapting to change. It continues to change, even without the pronounced influence of modern man.

Before the arrival of modern man in the early nineteenth century, it can reasonably be assumed that major factors influencing the status and distribution of wildlife were those which influenced their habitat, such as climate and fire, as well as intrinsic factors influencing the animals themselves, such as disease and overpopulation. Man had very little impact on wildlife.

Climate

As recently as 14,000 years ago the region that is now Banff and Jasper was little more than a sea of ice and snow, with islands of rock here and there. As the climate grew gradually warmer and drier the ice began to retreat. Vegetation quickly became established on the glacial rubble, and wildlife followed.

Geist (1975) has drawn an interesting picture of periglacial faunas, based on the processes that can be seen functioning in the Yukon's St. Elias Range. Far from being barren and devoid of life, the vicinity of large glaciers represents a productive and climatically favourable environment for ungulates and other wildlife. A mosaic of early-successional vegetation nourished by glacial silt, frequently frozen while still green, combined with low snow accumulation due to winds off the valley glaciers, would have encouraged the early spread of bison, elk, deer, sheep and mountain goats into the lower valleys of Banff and Jasper.

As forests developed and replaced the earlier successional vegetation, gradual changes in wildlife distribution would have taken place. During the period between 7000 and 3500 year ago, the climate was much warmer than today (Heusser 1956). Grassland and fire-successional vegetation would have been more extensive, with a corresponding abundance of bison, elk and mountain sheep. Moose and caribou were probably uncommon during this period.

The five centuries between about 1350 and 1850 are known as the "Little Ice Age" (Heusser 1956). A minor glacial advance took place during this period as a consequence of cooler temperatures and higher precipitation. This period was one of re-entrenchment of coniferous forest throughout much of the Rocky Mountain region and was probably more optimal for caribou, moose and bison than for ungulates such as elk and deer which rely on open vegetation and shallow snow (Stelfox and Taber 1969). The montane grasslands and forests, however, and the grassy subalpine slopes along the Front Ranges which had become established during the earlier warm period survived the Little Ice Age as a consequence of the local climatic conditions that maintain them today. While travelling down the Bow valley in 1859, the Earl of Southesk (1875) observed "... groups of really large pines [Douglas Firs]... ten to twelve feet in girth." These montane forest stands would have been well over 200 year old.

The continued retreat of glaciers in the Rockies indicates that the climate has been growing gradually warmer since the 1850's (Heusser 1956). This warming trend has led, possibly, to some expansion of the highly valuable montane ecoregion. It may not necessarily, however, have led to improved conditions for ungulates. Geist (1975) indicates that during glacial retreats the band of favourable habitat in the vicinity of glaciers shrinks rather than expands and winter severity increases. Major winter kills have been documented periodically since 1840 (Stelfox and Taber 1969), including 1847/48, 1886/87, 1887/88 and 1906/07.

Stelfox and Taber refer to drought periods during the 1820's, 1860's, 1890's and 1930's which reduced the amount of forage available to ungulates while increasing the frequency of forest fires. These droughts caused temporary reductions in carrying capacity for ungulates and led to the creation of new habitat through fire.

Fire

In 1800 David Thompson noted the presence of small burns along the upper Red Deer River (Hopwood 1971). Indians told James Hector of great fires in the region in 1847 (Spry 1968) and the Earl of Southesk (1875) also referred to "endless tracts of charred and decaying remains" in the lower Bow Valley. Fire evidently played a major role during pre-historic times both in temporarily destroying range and thus reducing wildlife populations, and in creating new stands of early successional vegetation. The frequency and extent of such fires would have varied from year to year and decade to decade, depending on climatic factors (C. White, Banff Warden Service, pers. comm.).

Disease

Indians told the Palliser expedition (Spry 1968) and Moberly (1884) of a disease which killed numerous elk, moose, deer and bison in the North Saskatchewan valley in 1847. Disease may have accounted, in part, for the disappearance of wood bison from the Rockies by the early 1800's (Ogilvie 1979) but there is little likelihood of its ever having been a major factor in contolling wildlife numbers. Disease generally manifests itself only in wildlife populations already stressed by over-crowding or other factors. The possibility exists that the disease referred to by Hector may have been introduced by livestock.

Man

Man's influence on wildlife in the Rockies, prior to the introduction of firearms, was probably local and sporadic. The Stoney (Assiniboine) Indians hunted throughout the region (Hopwood 1971). A small band known as the Snake Indians frequented the Athabasca valley and were noted for their method of snaring sheep, bear and bison. Ungulates were also killed by chasing them off cliffs or "pounds". At one pound between the Snake Indian and Wildhay Rivers the Indians killed "... some moose, some deer, but mainly buffalo" (Vincent Wanyandi in MacGregor 1962).

Further south, David Thompson encountered Peigan and Kootenai Indians in the Bow and Red Deer valleys during the early 1800's (Hopwood 1971). It appears that native hunting was relatively inefficient, seasonal, and confined to the larger valleys of the Front Ranges prior to the advent of firearms. There is some evidence the prehistoric native populations frequented the Rockies for many centuries. Christensen's (1971) survey of Banff archaeological sites "... demonstrates the widespread penetration of aboriginal populations into inter-montane valleys... to relatively high altitudes in the mountains... ".

1.3.2 WILDLIFE IN THE ROCKIES - EARLY HISTORIC TIMES (1800 - 1915)

The fauna encountered by the earliest European visitors to the Rocky Mountains was somewhat different from that which occupies Banff and Jasper today. Bison, for example, were widespread in both Banff and Jasper, observed by David Thompson in the North Saskatchewan and Athabasca River valleys and by the Palliser expedition in the Pipestone River Valley (Spry 1963). Moose and caribou were more abundant and widespread than today (Douglas 1914, Moberly 1929, Spry 1963). The prevalence of these species in the early nineteenth century reflected the boreal conditions associated with the Little Ice Age (Stelfox and Taber 1969).

Because of the variability between one part of the Rocky Mountains and the next with regard to local climate and habitat conditions, fire history, hunting pressure by natives, and the accuracy of reporting by early explorers, the status and distribution of wildlife in the early 1800's is a patchy and incomplete story. In general, the history of the nineteenth century is one of declining populations of all the large mammals in the Rockies.

> In the Red Deer River valley in 1800, David Thompson reported that: "... buffalo, red deer [elk], moose, and small deer are... plentiful and grizzled bears but too many".
>
> (Hopwood 1971)

He killed a fisher, which he considered common in the foothills, as were wolverine (Hopwood 1971). Eagles, too, were evidently common, as he reported that Indians killed eight on 12 October 1880. Moberley hunted in the area that is now northern Jasper in the 1850's and reported that:

> "bighorn and caribou were almost always in sight... We killed more than seventy moose on the trip, besides many bighorn, caribou and mountain goat".
>
> (Moberley 1929)

The abundance of game in the early 1800's appears to have been general throughout the Rockies. It had given way by 1915, however, to conditions of general scarcity (Millar 1915). The reasons given for this decline include overhunting by both whites and Indians (Moberley 1929, Millar 1915, Stelfox 1971), competition for forage with domestic livestock (Stelfox 1971), severe winters (Spry 1968, Soper 1970), disease (Moberley 1929, Spry 1968), habitat loss to fir (Millar 1915) and predation (Stelfox 1971).

Overhunting

Overhunting was the major cause of declines in game populations in the Rockies. The development of fur trade forts at Rocky Mountain House, Jasper House and Henry House led both to a great demand for fresh meat in the area and to the arming of the natives with firearms. Both the intensity and the efficiency of hunting were increased.

In about 1850 Henry House was:

> "... in its heyday as a post devoted to provisioning the many brigades that continually passed to and from the West Coast. The Hudson's Bay factor kept the Indians hunting and bought all the meat they could bring in... "
>
> (Vincent Wanyandi in MacGregor 1962)

Moberley (1929) described a hunting trip out of Rocky Mountain House in 1855 involving 180 people and 150 horses, which headed into the mountains along well-worn "pitching trails" that had been used by hunters for years. Such a group, he reported, would camp in an area for two or three weeks until it was "hunted out". Moberley's party killed "more than seventy moose on the trip, besides may bighorn, caribou and mountain goat."

As the fur trade in the Athabasca Valley gave way to prospecting, railroad construction and settlement in the Athabasca and Bow Valleys toward the end of the century, the human population of the Rockies, and its demands on wildlife, skyrocketed.

> "Since 400 to 600 resident Stoney Indians were annually taking 2000 to 3000 wild ungulates between 1913 and 1915 (Millar 1915), 10,000 miners and large numbers of other Indians must have been taking a considerable annual big game harvest from 1880 to 1915, when domestic meats were scarce."
>
> (Stelfox 1971)

Millar (1915) reported that big game was extinct within 25 miles of mining communities in the Rockies by 1915, due to the efforts of local hunters.

Range Competition

Horses were the primary mode of transport in the Rockies until well into the twentieth century. Cattle were frequently kept by early settlers to provide meat and dairy products. Between 1880 and 1915 more than 5000 horses were grazing on the east slopes and lower valley of the Rockies (Stelfox 1971). Cattle were grazed in the Athabasca and North Saskatchewan valleys (MacGregor 1962) and as late as 1922 there were 323 cows and 432 horses grazing in the Bow valley (Bow Valley Naturalists 1978). Hay was also cut for winter livestock feed around the Vermilion Lakes and lower Athabasca valley.

The loss of forage to domestic livestock would have been especially critical to native ungulates during the three severe winters documented between 1880 and 1915 (Stelfox and Taber 1969) when snow conditions limited the availability of what little forage remained. The main livestock grazing areas were in the montane valley bottoms of the Athabasca, North Saskatchewan and Bow Rivers, areas which were also highly important

ungulate winter ranges.

Grazing animals such as elk, sheep and to a lesser degree, mule deer would have been the species suffering most directly from competition with livestock.

Severe Winters

There were several bad winters in the 19th and early 20th centuries. James Hector was told by Indians that many elk and bison had been killed by a severe winter some time before 1859 (Spry 1968). Severe winters in 1886/87 and 1887/88 were considered responsible for the extermination of bison and elk in the Peace River region (Soper 1962, Stelfox 1964). Millar (1915) and Stelfox attributed the elimination of elk from nearly all their historical ranges to the famous winter of 1906/07 when more than half of all the cattle in Alberta were killed.

Habitat Loss to Fire

In 1859 James Hector was told by Indians that the North Saskatchewan River valley had once

> "... been rich in game, but eleven years earlier, 1847, there had been great fires all through the mountains and in the woods along their eastern bases; after that a disease had broken out... so that they used to find wapiti, moose, and other deer, as well as buffalo, lying dead" (Spry 1968)

Hector himself contributed to the destruction of wildlife habitat by fire

> "... during the night we saw a great glare of flame down the valley, and we rightly conjectured that the fire we left at our halting place had set the forest on fire" (Spry 1963)

Fire was a common occurence at the turn of the century. Carleton (pers comm.) reported that early prospectors commonly set fires in order to expose rock strata or to mark areas for further reference. During the railway construction years of 1882 to 1885 in Banff and 1911 - 1913 in Jasper, many fires burned unchecked along the Bow and Athabasca valleys. It was not until almost 30 years after the completion of the CPR through Banff that the first organized fire control was initiated (Harmon 1959).

Fires set deliberately or by accident by early prospectors, settlers, hunters and railroad builders removed far greater amounts of forest than in pristine times. Although these vast burns contributed to the large game populations of the mid-twentieth century, their immediate affect was to reduce catastrophically available cover and forage.

Disease

There is little reference to disease among wild ungulate populations prior to 1915, other than Hector's report of an undetermined epidemic among the elk, moose, deer and bison of the North Saskatchewan valley in 1847 (Spry 1968). The impact of brucellosis, tuberculosis and anthrax upon the plains and wood bison of eastern Alberta has been well documented (Ogilvie 1979) and the impact of the pneumonia lungworm complex on bighorn sheep has also been described (Stelfox 1971). There is a possibility that disease, either naturally-occurring or introduced with domestic livestock, may have contributed to the decline of ungulate populations, particularly bison.

Predation

Stelfox (1971) refers to Brown's (1914) report that 1000 wolves were poisoned in southern Alberta in one winter in the 1860's and to indications by Coues (1897) and Spry (1963) that wolves were common in the Rockies during the early 1800's. Doubtless wolves, in addition to cougars - which were, however, largely confined to the lower Bow valley and areas farther south (Southesk 1875) - exerted a significant influence on bison, moose, elk and other ungulates during the nineteenth century. The extensive use of poison and traps during this period, however, no doubt contributed as much to increasing scarcity of predators as did over-hunting to their prey (Millar 1915).

Summary

A combination of factors, particularly over-hunting by the growing and increasingly well-armed human population of the Rocky Mountains, led to the gradual depletion of wildlife throughout the regions of Banff and Jasper by 1915. Bison had been extirpated by the 1860's and elk were gone from all but the Brazeau and Kananaskis valleys by 1906 (Millar 1915). Bighorn sheep had declined from more than 10,000 in the 1850's to fewer than 3,000 by 1915 (Stelfox 1971). Large carnivores and ungulates were rare throughout the Rockies and only the mountain goat was still relatively widespread and abundant (Millar 1915). Fire had devastated large parts of the main river valleys. Domestic stock were heavily grazing the important winter ranges and exposing native ungulates to a host of new diseases.

1.3.3 PARK ESTABLISHMENT: THE BEGINNING OF WILDLIFE MANAGEMENT

Prior to the twentieth century most wildlife management in the Rocky Mountains was achieved by bullets, traps and poison. Neither social conscience nor social institutions had evolved yet to the point where wildlife might have any imminent hope of respite from the continuing depletion to which it was subject.

One of the first steps towards positive wildlife management was the establishment of national parks at Banff [1885] and Jasper [1907]. National Parks were a new phenomenon, though, an institution that had never existed prior to 1872 when Yellowstone National Park was established in the United States. Parks were set aside more for tourism and recreation than for preservation, and parks policy developed only gradually towards an ideal of effective wildlife preservation and management. Policy could only be as enlightened as the public attitudes that it reflected, and the conservation ethic would not become widespread until the mid-twentieth century.

Banff and Jasper National Parks were established at different times, in areas having very different histories of human occupation and development. A parks policy was already developed and both regulations and the means of enforcement existed by the time that Jasper came into being.

BANFF

Banff National Park had its beginnngs in a dispute over the ownership of some hot springs at the foot of Sulphur Mountain. These springs were discovered in 1883, at a time when the population of the Bow River valley was peaking. That year the Canadian Pacific Railway was being built through the valley and a large railhead town had been built at Laggan (Lake Louise) (Harmon 1959). A thousand miners were living at Silver City, a short-lived boomtown at the foot of Castle Mountain.

The co-owners of the hot springs had a falling out when one agreed to sell the claim without consulting the other. The ensuing legal dispute was solved by the Federal government when it expropriated the land, setting aside a 10 mi² reserve to be developed as a health resort and recreation area for the people of Canada. This hot springs reserve, established on 25 November 1885, became the nucleus of Canada's national park system.

Although the hot springs reserve was originally set aside for health and recreation and not for preservation of natural features or wildlife, wildlife concerns were expressed as early as 1886 in Whitcher's report on his investigations into the problems and potential of the new park reserve. He mentioned the depletion of wildlife:

> "Large game and fish... are now scattered and comparatively scarce. Skin hunters, dynamiters and netters, with Indians, wolves and foxes have committed sad havoc. The rapid settlement now progressing... will add other elements of destruction."
>
> (Whitcher 1886)

Among his recommendations was one pertaining to wildlife management:

> "Wolves, coyotes, foxes, lynxes, skunks, weasels, wild cats, porcupines and badgers should be destroyed. The same may be said of eagles, falcons, owls, hawks and other inferior rapaces. Also, mergansers, kingfishers and cormorants."
>
> (ibid.)

This advice reflected the prevailing attitudes of the time and was, in fact, a reasonable paraphrasing of park policy for 70 years after Whitcher's report.

Partly on the basis of this report the first Rocky Mountain Park Act was passed on 23 June 1887. It established a 260 mi² park that included Lake Minnewanka (Harmon 1959). Three years later, on 30 June 1890, the first regulations governing hunting were established:

> Regulations Governing Park - No. 1694
>
> 29. The shooting at, wounding, capturing, killing or in any manner injuring wild animals or birds within the park is hereby prohibited excepting, however, mountain lions, bears, wolves, lynxes, wolverines, coyotes, wild cats, and hawks. Fishing with nets in any of the waters of the park is also prohibited.

However, these regulations would have little effect for almost 20 years, since it was not until 1909 that the Federal Government hired H. E. Sibbald as Chief Game Guardian along with the first wardens.

Thus, by 1890, the first policy and regulations with regard to wildlife protection had been established. Over-exploitation by humans was acknowledged and - if predator control was somewhat overemphasized - this was still in keeping with the state of man's understanding of nature at that time.

The 1880's were pivotal years. Not only did the first national park come into existence in that decade, but many of the processes that would influence the development and dilemmas of wildlife management in the Rocky Mountain national parks were becoming evident.

Elk, for example, were decimated by over-hunting in the 1880's (Millar 1915) and by the notably severe winters of 1886/87 and 1887/88 (Stelfox 1964). The numerous fires associated with railway construction in the 1880's would lead to ideal range conditions that allowed elk populations to boom 50 to 60 years later and to the extensive lodgepole pine forests that would contribute to their decline 80 to 90 years hence.

The railroad, built between 1882 and 1885, was the first transportation artery through the park, setting the stage both for the continuing loss of valley-bottom habitat to development and for one of the major management problems of the 1970's and 1980's - wildlife mortality on railroads and highways.

The predator-control emphasis of early park regulations, though later removed, foreshadowed more than half a century of active predator removal and controversy.

As early as 1886 the Banff townsite was being surveyed on the alluvial fans of the Spray River and Fortymile Creek and 100 leases were given out. The townsite, with its inevitable expansion and the concentration of visitor facilities around it, set the stage for the on-going incremental loss of Banff's highly valuable montane ecoregion.

Jasper

The Athabasca valley had been largely abandoned by people for almost half a century by the time that Jasper National Park was established in 1907. Use conflicts were fewer than in early Banff, although this would change with the coming of the railroads in 1911. Although the rationale for the park's establishment was still the development of tourism and recreation, wildlife protection was an acknowledged part of this development and parks policy and regulations already existed, along with an administrative framework.

The Athabasca valley experienced two populations booms, but was never exposed to the same sudden surge of growth experienced by the Bow valley in the 1880's. The first cycle of population growth centered around the fur trade of the mid-1800's. As early as 1811 the first trading posts were established in the Athabasca valley as the more southerly Howse Pass trade route to the Columbia fell into disrepute because of Indian problems (Hopwood 1971). By the 1850's Jasper House was "... in its heyday" (MacGregor 1962). The Overlanders used the Athabasca trail over Yellowhead Pass in the 1860's and further increased the human use of the valley. However, the development of the Pacific Coast and interior British Columbia led to abandonment of the overland trail routes by the 1870's (Soper 1970).

By the end of the nineteenth century the area that would become Jasper National Park supported only a few trappers and packers, and seven homesteaders in the Athabasca valley (MacGregor 1962). Ungulates had been depleted and on the grasslands of the lower Athabasca there were no more elk or bison, only horse herds belonging to the Dominion Government (MacGregor 1962, Soper 1970).

Jasper National Park was established in 1907 in anticipation of the construction of the Grand Trunk Pacific Railroad through Yellowhead Pass. The government bought all the freehold land within the boundaries of the new park, except for the Lewis Swift homestead which remained in private hands until the 1960's (Soper 1970). The park headquarters were established near the present Jasper townsite. Four years later the railroad arrived, bringing the second population boom to the Athabasca valley. The impact of this boom was far less than in Banff; in Jasper the park arrived first.

1.3.4 WILDLIFE PRESERVATION AND MANAGEMENT

Wildlife management in Banff and Jasper has evolved since 1885 when the presence of wildlife was not even considered a factor in the establishment of the first national park, through the era of wildlife preservation and predator control, to the 1960's and 1970's when public environmental awareness and the flowering of the science of ecology created a demand for intensive study and management of wildlife and habitat. Preservation and inventory of wildlife were the earliest expressions of management and both continue to be important today. Wildlife management has been influenced by land-use problems and habitat change and by public attitudes and perception of wildlife. The following discussion outlines the development of wildlife management.

1. Wildlife Protection

At the time of the establishment of Banff and Jasper National Parks wildlife - particularly ungulates - was severely depleted in the Rocky Mountains. Concern for the protection and restoration of wildlife was expressed officially as early as 1886 (Whitcher 1886; see above), and a regulation was passed in 1890 prohibiting the killing of all wildlife except predators. Wildlife protection was thus the earliest form of wildlife management in national parks and remains important today.

Wildlife protection on paper, however, was not wildlife protection in fact. The first wardens to enforce wildlife regulations were not hired until 1909 (BPAF), at a time when hunting was still being conducted openly near Banff townsite. In 1910 Norman Luxton was charged by the new park wardens for shooting two sheep in the park. He retaliated by charging the wardens with killing coyotes, but the Crown dropped the case against the wardens, saying they had authority to kill coyotes (OOA).

The exclusion of predators from the slate of animals to be protected in parks was consistent with the state of wildlife conservation awareness of the time. The game reserves of Europe were the obvious model upon which to base wildlife policy, there not being any widespread understanding of or concern for the interrelationships among wildlife. Predators killed the kinds of animals which tourists wanted to see and were consequently considered undesirable.

Wildlife was protected in this selective manner until 1924, when Parks commissioner J. B. Harkin requested that the Superintendent of Rocky Mountain National Park provide him with a list of animals being shot in the park in the belief that they are harmful. Superintendent Stronach replied:

> "the following are shot and trapped in the park:
> coyote, mountain lion, wolverine, lynx, weasel, porcupine, pack rats, squirrels (sometimes), mink (sometimes), magpies, crows, eagles, ravens, sharp-shinned hawks, Cooper's hawks, osprey and goshawk..."
>
> (B.P.A.F.)

In October 1924 Harkin informed Stronach that weasels and lynx were not to be destroyed. Following a further exchange of correspondence in which Stronach complained that wardens had treed four lynx in the Kananaskis and had not been allowed to kill them, Harkin informed the Superintendent that parks policy was that:

> Excessive reductions in numbers of predatory animals and birds which act as controls will usually result in trouble. It is held that the policy should be to have wildlife conditions in the National Parks as natural as possible.
>
> (B.P.A.F.)

In spite of this enlightened attitude of the Ottawa parks administration, some local administrators were less inclined to view predators as wildlife deserving of protection. Superintendent Stronach agitated long and frequently and at length persuaded Harkin, in March 1928, to add cougars to the list of carnivores to be killed on sight rather than

when due cause could be proven (B.P.A.F.).

A 1932 Montreal Gazette article (3 February) reported that cougars were wiping out the wildlife in Banff National Park and should be eliminated. In December of that year the Banff citizens adopted a resolution that wardens should kill cougars, coyotes and other predatory animals. Public and media pressure added weight to the concerns of the local park administration and in March 1933, Ottawa distributed a Policy Governing Predatory Animal Control in the National Parks of Canada :

* To be shot on sight: wolf, coyote, wolverine, and cougars.
* Wardens may use dogs to hunt cougars.
* If predators increase to such an extent as to threaten wildlife the Superintendent is to report to head office.
* No animal other than the above is to be killed unless it poses a menace to human life or causes serious property damage.
* Traps are prohibited except around paddocks when necessary.
* Hides and pelts are government property.
* Wardens are to keep careful game records.
* Birds to be killed on sight: Goshawk, Cooper's Hawk, Great Horned Owl, Crow and Magpie.

(OOA)

Although the list of animals to be killed on sight was reduced to four mammals and five birds, this did not mean that there was to be any reduction of effort directed towards them. In fact, during the 1930's Harkin expressed concern on several occasions (OOA) that wardens were not killing enough coyotes in Banff. In 1935, the park hired a professional cougar hunter to reduce the cougar population. He killed nine cougars the following year; five others were killed by wardens (BPAF).

In the mid 1930's, the Alberta Fish and Game Association began actively lobbying the National Parks for more predator control, claiming that Parks were breeding grounds for cougars and other predators. The Calgary Herald joined the outcry with an editorial on 24 November 1938 saying that coyotes were thick, cougars thriving, and martens and weasels killing all the birds in the parks.

In order to achieve an objective assessment of the situation, the National Parks commissioned Dr. R. M. Anderson of the Dominion Wildlife Service to investigate wildlife conditions in the Rocky Mountain national parks. His report (Anderson 1938) and a subsequent report by C. H. D. Clarke, also of the D. W. S., recommended against further predator control (Clarke 1942).

The controversy continued, with a Mr. Fisher of the Alberta Fish and Game Association making increasingly outrageous claims about the predator situation in parks and officials of the National Parks and the Dominion Wildlife Service refuting them. While the correspondence (OOA, BPAF) became voluminous and redundant, the controversy led to some excellent wildlife investigations and served to focus the attention of park managers more directly on the need for a consistent wildlife policy for parks.

Nonetheless predator control, particularly of coyotes and wolves, continued through the 1940's and 1950's. In 1953 the fear of a rabies epidemic prompted intensified efforts, including the use of strychnine, to eliminate canids in the parks. Poison, which had been prohibited prior to this, was allowed until 1959 when at long last a circular was distributed rescinding the 1953 rabies instructions and stating that there was:

> "... no reason for predator destruction anywhere insofar as wildlife management is concerned"

(B.P.A.F.)

The era of predator control ended officially with the 1959 circular which, in effect, gave all wildlife equal status in National Parks. Predators could still be destroyed if they posed a threat to humans or property, but game protection was no longer considered a valid reason.

As late as 1968, however, coyotes were still being killed in the parks. A memo from the Superintendent of Banff to the Parks Director in Ottawa in 1968 affirmed that a cougar and ten coyotes had been killed that year by wardens. Total protection of park wildlife did not apparently become fact until the 1970's, almost a century after the establishment of Banff National Park.

2. Wildlife and Habitat Inventory

The necessity to catalogue park resources, including wildlife, was recognized when the first Rocky Mountain Park was established. The earliest attempt at wildlife inventory was Whitcher's investigation of 1886 which was somewhat less than accurate (Whitcher 1886). Whitcher's inclusion of pronghorns in his list of the park's fauna, and his description of the elk as being the "foremost" of the deer family when it was, in fact, nearly extirpated, suggests that his information was not gathered in the field.

Much of the earliest inventory work in the Banff and Jasper areas was done prior to National Park establishment, sponsored by American museums and other institutions. In 1826 Thomas Drummond, a zoologist on the second Sir John Franklin expedition compiled a list of mammals in the Jasper area including the first Richardson's water vole, northern flying squirrel and pika known to science (Soper 1970, Drummond 1830, Richardson 1829). The following year David Douglas, a botanist, accompanied a Hudson's Bay clerk over the Athabasca Pass and also compiled a list of birds and mammals (Douglas 1914).

Subsequent travellers through the Rockies recorded wildlife observations in their journals, but the next scientific attempt to catalogue animals was not until seventy years later with the arrival of Alden Loring of the United Stated Biological Survey at Jasper. His and subsequent biological expeditions have been described by Banfield (1958) and Soper (1970).

The public controversy over predator control in Banff and Jasper National Parks led to a series of investigations into wildlife conditions in these parks during the late 1930's, 1940's and 1950's (Anderson 1938; Clarke 1940, 1942; Cowan 1943, 1944, 1946a,b, 1947a,b; McGuire 1952). Banfield (1953) conducted the first aerial game census in Banff and Jasper. Clarke and Cowan (1945) and Cowan (1955) produced annotated checklists of the birds of Banff and Jasper, valuable first attempts at inventorying park avifauna. The reports also indicated that, at least to some, wildlife in National Parks was defined as more than bears, ungulates and predators.

Banfield (1958) in Banff and Soper (1970) in Jasper summarized their own and all previous published field work to prepare annotated accounts of the mammals of these parks. No comparable work had been produced with regard to birds, amphibians or snakes prior to this report.

Before the 1970's most attempts at wildlife inventory in Banff and Jasper consisted of species lists and general comments on status and distribution. With increased development of and pressures on the parks in the late 1960's and a perceived need for more accurate resource data for informed park management, these early attempts - excellent in their time - were no longer sufficient.

In 1970, a Parks Canada Resource Inventory Task Force was struck to assess the state of present resource knowledge, to identify gaps in this knowledge and to facilitate the filling of those gaps. This task force took advantage of the expertise available in other federal agencies such as the Canadian Wildlife Service, Geological Survey of Canada, Canada Department of Agriculture, Canadian Forestry Service and National Museums of Canada to establish program objectives and terms of reference.

The upshot was that Parks Canada began a Resource Inventory Program in 1971 with pilot projects in three parks across Canada, including Waterton Lakes National Park. The early resource inventories dealt with each resource component in isolation from the

others. This led to a number of difficulties including duplication of field logistics, inability to reflect ecological relationships, and problems with integrating the results of separate soil, vegetation, mammal and bird inventories, frequently conducted at different mapping scales and levels of sampling intensity (Day et al 1975).

These problems became apparent during and after the resource inventories of Waterton Lake (1971 - 1977) and Yoho (1973 - 1977) National Parks, at about the same time as the biophysical approach to resource inventory was being developed (Lacate 1969, Day et al 1975). Consequently the Resource Inventory Task Force agreed that the Banff and Jasper resource inventory would take a biophysical approach; it would integrate geology, soil, vegetation and wildlife in a single land classification and mapping scheme (Parks Canada 1976). The integration of wildlife data in developing a biophysical classification had not been attempted prior to the Banff and Jasper inventories.

The Banff-Jasper wildlife inventory began in 1974 with preliminary field work in the Bow and Athabasca valleys, mainly to develop and refine methodologies and to explore means of integrating wildlife inventory with land inventory (McGillis et al 1976, Oertli and Stelfox 1975, Stelfox et al 1975). The land classification team, comprised of scientists from the Canadian Forest Service and Alberta Institute of Pedology, began field work in 1974 and continued until 1979, sampling a different portion of the two parks each year and producing interim reports on each year's work.

The wildlife inventory team, comprised of scientists from the Canadian Wildlife Service, conducted field work in the same areas as the land inventory team, but sampled each area one year later in order to have the benefit of the interim mapping and classification material. Consequently, wildlife sampling continued from 1974 until 1981. This system allowed continual consultation among members of the Biophysical Inventory Team and enabled the wildlife team to have input into the development of the classification methodology (Holroyd 1979b, Van Tighem and Holroyd 1981).

This final report of the wildlife inventory, in conjunction with the final report of the land inventory, represents the culmination of the latest stage in the evolution of wildlife inventory in Banff and Jasper National Parks. It was conceived as a vital management tool and is presented in a manner to facilitate its use as such; future needs as yet unanticipated will lead to further evolution in the theory and practise of wildlife inventory in these parks. Inventory reflects what is present at a given place and time. Monitoring of landscape change, land-use change, and inevitable shifts in the distribution and numbers of wildlife are essential in order to ensure the continued usefulness of this inventory.

3 Land-use and Resource Exploitation

Any attempt to manage wildlife is ultimately dependent on - and often confounded by - land-use practises which influence animals and their habitat. Land uses which have affected the wildlife of Banff and Jasper National parks include boundary changes, development of access and facilities, mining, logging and hydropower development.

Boundaries

The boundaries of Banff and Jasper have not remained static over the years. In 1885 the park reserve at Banff was only 26 km² (10 mi²) in area. Following Whitcher's report and recommendations the park's boundaries were set at 673 km² (260 miles²) in 1887. A number of boundary changes took place in the ensuing years with the park attaining a maximum size of 12,691 km² in 1902, including the Kananaskis, Ghost, Burnt Timber and Red Deer watersheds as well as the Bow valley east to Seebe. In 1912 the boundaries were slashed to only 4662 km².

The reduction of the Rocky Mountains Park to only a third of its former size in 1911, at a time when ungulate populations were still very low (Millar 1915), led to concern by local park authorities that game would be further depleted in the areas removed from park status areas. The Alberta Government, however, set the released areas aside as game preserves and wardens were assigned to patrol them (BPAF, OOA). In the early 1940's, with game populations fully recovered, these areas were opened to hunting (BPAF).

In 1928 there was correspondence between Banff and Ottawa concerning the status of the northern part of the park area. The park was informed that since the boundaries were unsettled the area would be open for hunting (BPAF). In 1930 with the passage of the National Parks Act, and the relinquishment of Alberta's natural resources by the Federal Government, the boundaries were established near their present locations. Hunting was curtailed north of the Clearwater River and east of the Siffleur (Calgary Herald, 28 August 1930).

The final boundaries of Banff National Park, set in 1949, enclose a 6644 km² area of largely subalpine and alpine terrain, almost evenly divided between the Main Ranges and Front Ranges of the Rocky Mountains. The area is large enough to include populations of most wildlife species sufficiently large to be viable over the long term. Some problems with management of wildlife have arisen, however.

These are primarily related to the exclusion of most of the major ungulate winter ranges from the park. The Kootenay Plains, Ya-ha-tinda, Corners and Canmore Flats areas, in addition to many smaller areas, are areas once noted for their wintering ungulate populations (Southesk 1875, Spry 1968, Hopwood 1971) and now excluded from Banff National Park. Elk and deer that summer in Banff move outside the park in winter, creating management problems with regard to both the ungulates and their predators. Banff is only marginally capable of sustaining wolf populations, in particular, because of the exclusion of the lower Clearwater, Red Deer, Panther and Ghost watersheds from the park (Carbyn 1974b; see wolf species account below).

In Jasper, boundaries also changed following the establishment of the park in 1907. At no time did the park shrink to the size of Banff though, and its final boundaries enclose 10,878 km². This includes extensive montane areas in the Athabasca, Miette and Snake Indian valleys, as well as lower subalpine winter ranges in several other watersheds. Management problems with wildlife using adjoining provincial land did not develop to the same extent in Jasper as in Banff because of the greater size and geographical integrity of the park. One exception of note, however, involves caribou using the northern part of the park (See caribou species account below). The exclusion of the boreal lands northeast of the park resulted in the exclusion of several boreal wildlife species from all but a very small part of the lower Athabasca watershed (see watershed account below).

Access and Facility Development

The invasion by civilization of what was only recently wilderness gave rise to popular statements of regret even before the establishment of the national parks. However, there appears to have been little specific concern about habitat loss, wildlife disturbance and other impacts of development prior to the 1950's. It was felt that if animals were protected from hunting and predators they would prosper, and if some habitat was lost in some areas they could move to another. This optimistic attitude was no doubt encouraged by the steadily-increasing populations of ungulates in the Rockies during the first half of this century and by the great extent of relatively undeveloped land in the West.

With the development boom of the 1950's and 60's, however, came an awareness that some vital wildlife areas were being excessively altered. Hubert Green's correspondence in the early 1950's (ACR) includes expressions of concern about the siting of campgrounds and roads in the parks. W. Mair (1952), in a report on elk in Banff

predicted that:

> "... the new, proposed trans-Canada highway through the winter range of one major elk herd in the park, and through the chief summering range of the moose, will be a major blow to these species... "

History showed that he was right (Flygare 1978, Holroyd 1979a).

The 1960's were a period of awakening environmental awareness during which the public and media began to add their voices to those wildlife experts and park managers who were already warning of the impact of development on wildlife. This concern came to a head in 1971 when the National and Historic Parks Branch held public hearings into provisional master plans that had been developed for Banff, Jasper, Kootenay and Yoho National Parks (Parks Canada 1971, 1974).

The master plans called for a major development initiative in the four parks which would include 18 new or upgraded roads, three new visitor service centers and modernized, expanded campgrounds. The public response was unexpectedly strong and reflected a much greater and better-informed level of public interest in the management of National Parks than ever before.

The overwhelming majority of briefs presented at the public hearings, and at public hearings held two years later on a proposed major ski development at Lake Louise, were opposed to uncontrolled expansion of access and visitor facilities (Parks Canada 1974). Although wilderness aesthetics and preservation of natural beauty figured heavily in the concerns expressed by citizens, a great many were concerned about the integrity of park ecosystems and the maintenance of wildlife populations.

In response to this public concern about the impact of development on park environments and wildlife, the Lake Louise project was cancelled and the master planning process was set back pending completion of resource inventories (see above) and other studies. It also led to a renewed committment to environmental preservation in the 1979 Parks Canada Policy.

While the resource inventories of Banff and Jasper have provided and will continue to provide the basic information necessary to evaluate and predict the impacts of development on wildlife and its habitat, the procedure for evaluating impacts was begun in 1973. The Federal Government established the Federal Environmental Assessment and Review Process (EARP) that year. It was revised in 1977 (FEARO 1980). This structured approach to environmental impact assessment is now adhered to by all Federal agencies proposing development projects and all other agencies proposing projects that will affect Federal lands. Parks Canada's committment to the process is established in section 3.3 of the 1979 Parks Canada Policy.

Mining

Between 1883 and 1885 there was a copper-mining community of as many as 1550 souls at the foot of Castle Mountain in Banff (Scace 1969). At the same time, the first coal mining in what would become Banff National Park began at Anthracite. The Anthracite mine operated until 1904 and the nearby Bankhead mine, with its town of 1000 occupants, operated until 1923. These early communities contributed substantially to the depletion of game in the area (Millar 1915).

In Jasper the presence of minable coal had been noted by George Simpson as early as 1824. After the completion of the Grand Trunk Pacific in 1913 this coal was mined at Brule and Pocahontas.

The extraction and development of mineral resources was considered acceptable in the early days of park history since western Canada was still young and industrial development was needed to establish employment and revenue. In 1905 Superintendent Byrne of Rocky Mountains Park reported:

"The industrial assets of the park have been increased since last year by the establishment of a Portland cement mill... an important step in the building up of western Canada... "

(Byrne 1968)

With the passage of the National Parks Act in 1930 and the exclusion of the Canmore mines from Banff National Park, mining was no longer allowed in the parks. Mineral exploration by large oil companies using pack trains was allowed in the 1950's (Park files) but extractive activities have ceased.

Logging

Small logging operations were widespread in the Bow and Athabasca valleys during the early years and led to long-lasting modifications of wildlife habitat. Logged areas, with their open canopies, favoured grazing animals and species of disturbed and edge habitats, at the expense of those species dependent upon extensive, undisturbed climax stands. Logging was never extensive enough to create major habitat losses. Most of the logged areas have since regenerated to natural forest cover, but sawn stumps are visible in many places. Most logging was selective, and consequently the recovery of the forests was encouraged by the survival of understory vegetation and young trees.

Railway ties were cut in the Whirlpool River valley of Jasper and floated down to the GTP line. The Eau Claire logging company was granted timber berths in the Spray and Kananaskis valley in 1884 and later in the Cascade valley. Most timber-cutting, however, took place near the towns and railroads through the Athabasca and Bow valleys. Wood was cut for railway ties, domestic and steam locomotive cordwood, and building materials.

Eau Claire relinquished its rights to the Bow Valley timber berths in 1897 (Byrne 1968), but retained rights to the Spray valley berths and continued logging there until the 1930's (Harmon 1959). Logging led to the accumulation of slash and has been implicated in some of the fires that burned the Spray valley early in the century (Byrne 1968).

Timber regulations were passed in 1905 to establish a permit system and in 1915 to control the cutting of green timber. The 1930 National Parks Act perpetuated the cutting permit situation. Further amendments and regulations came about in later years, but by then logging had ceased in Banff and Jasper.

Hydro-power Development

The potential for developing hydropower in the narrow valleys of the Rocky Mountains and their foothills was recognized early in the century, but Banff and Jasper were largely spared. The Astoria River in Jasper was tapped for local power but this development did not involve the construction of a major storage reservoir and had little impact on the park or its wildlife.

In Banff, however, a major part of the park's limited montane ecoregion, an area of considerable importance to wildlife, was flooded in 1912 and 1941 to provide power for southern Alberta.

George Simpson was the first to report on Lake Minnewanka in 1841, noting that Indians lived there at the time. In 1847 the Reverend Rundle described the trail to Devil's Lake, as it was then known, as a "hard-packed road." The broad, wind-blown valley was at that time a major ungulate winter range. By 1941 most of this valley was inundated under 23.5 meters of water, and a large canal joined the reservoir to Two-Jack Lake. This development contributed substantially to the depletion of the montane ecoregion in the Bow River valley.

The incompatibility of hydro development with the preservation of wildlife habitat had been recognized by 1930 when the Parks Act was passed. The 1941 enlargement of the reservoir was only allowed because it was war-time and felt to be in the national interest (A. Anderson, Parks Canada, pers. comm.). The 1979 National Parks Policy confirmed the unacceptability of hydro development in national parks. A subsequent amendment (1981) to National Parks regulations again permits hydro development.

4. Fire Management

By the turn of the century forest cover in the Bow and Miette valleys, and elsewhere in Banff and Jasper, had been much reduced by fires (see above). Byrne (1968) suggested that the climatic warming trend evident since the early 1800's (Heusser 1956) created drought-like conditions coinciding with the arrival of the first Europeans in the mountains. The seemingly careless attitudes of Europeans to fire at that time exacerbated the existing conditions of high fire hazard.

Dawson (1881) noted that the Bow, Kananaskis, Spray, Cascade and Red Deer valleys were largely burned over. In 1882 Ritchie (in Byrne 1968) reported that:

> "the Bow Valley from Banff through to the B.C. and Alberta summit was burned over by the engineers during a survey of the Canadian Pacific Main line... "

Tom Wilson (Banff Crag and Canyon, 17 July 1931) reported that Indians had told him of a dry summer around 1870 when most of the wildlife had been driven out or killed by the smoke. Henry Stelfox (1972) reported that the foothills region was so extensively burned in 1866 and 1887 that many Indian bands were forced to move elsewhere. Many early explorers commented on the evidence of forest fires in the areas that are now Banff and Jasper.

These widespread fires influenced wildlife management in Banff and Jasper in many ways. Burnt landscapes were considered unattractive and wasteful and doubtless their prevalence during the early part of the century led to strong feelings against deliberate burning in later years. In addition, so major a habitat change had far-reaching impacts on the parks' biota.

Initially, the impact of fires was to destroy vast amounts of habitat and to eliminate cover for those animals which survived. Since the late 1800's and early 1900's were a period of widespread over-hunting, the open post-fire habitats would have made wildlife even more vulnerable to exploitation.

With more effective wildlife protection in the first half of the century, and the succession of burnt areas to open grass and shrublands which were highly productive of browse, ungulate populations boomed. Elk, moose, deer and sheep all benefitted from the abundance of early-successional vegetation and their predators, especially wolves and cougars, consequently prospered as well. The abundance of predators, and their relative visibility in the open fire-successional habitats, doubtless were major factors in the predator control programs of the 1940's and 1950's. Similarly, the mushrooming ungulate numbers on a temporary abundance of forage led to populations too high for the resource base and resulted in the elk slaughters of the 1950's and 1960's.

The continued succession of vegetation on these burns has led to the prevalence of lodgepole pine forest in the major river valleys of Banff and Jasper today. Potential carrying capacity for ungulates and their predators has declined steadily at the same time as unnatural mortality has increased on roads and railroads. This mortality has been aggravated by the increasing importance of the grassy highway verges as grazing areas as fire-origin grasslands disappear under forest. Ungulate mortality on transportation corridors is thus, to some extent, associated with the fires of the 1800's and early 1900's.

In Jasper beginning in 1976, and in Banff beginning in 1979, controlled burning of second-growth pine forests is being explored as a means of reducing the homogeneity of vast tracts of forests where control of naturally-occurring or accidental fires is still essential because of the potential for injury to people or property. All fires in Banff and Jasper are still being extinguished even where they may benefit wildlife, mostly because of concern for public safety and the well-being of adjacent lands outside the parks.

5. Range and Ungulate Management

The history of wildlife depletion and subsequent recovery on fire-origin ranges has been covered in earlier parts of this section and is also dealt with below in species accounts. Active management of ungulates and their habitat was not practiced until the 1940's, when park authorities became concerned about a perceived over-population of elk in Jasper and Banff. Subsequently, concerns about other ungulate species such as sheep and caribou led to investigations of their status and range characteristics, but none received the same degree of intensive, active management as did elk. Ungulate management is discussed in the species accounts below.

6. Bear Management

Bears have been managed, mostly by gun, since the earliest days of Banff and Jasper. Only in the 1980's, almost forty years after the first documented reference to the problem (Banff Chief Warden Mitchell 1943, memo, park files) did effective garbage management begin to supplant the need to relocate bears or destroy them.

Beginning with the killing of a child by a black bear in Jasper in 1957, there have been several deaths and severe maulings by bears in National Parks in Canada (Herrero 1976). In the late 1960's a sudden increase in back-country use increased bear-human conflicts and led to another phase of bear management, that of studying bear ecology in order to minimize conflicts between bears and humans. Despite the much more intensive management of black bears, all research to date has concentrated on grizzlies.

Bear management is dealt with in greater detail in the bear species accounts below.

1.3.5 HUBERT UNSWERTH GREEN - SPECIAL WILDLIFE WARDEN 1940 - 1956

Managing and protecting park wildlife has always been a responsibility of the Warden Service. While the duties of wardens have become increasingly complex and time-consuming over the years, certain individuals have made exceptional contributions to the understanding and management of park wildlife. Many of these contributions have been poorly-documented, and it would be unfortunate if they were to be forgotten over the years.

One warden whose contributions were both remarkable and well-documented, was Hubert Green. His employment as Special Wildlife Warden in Banff National Park was an accident of fate but his contributions to the development of wildlife management and research in Parks were far ahead of their time.

It was probably due to the outbreak of World War II that Mr. Green, then 55 years old, was hired as Warden. Not only was he beyond normal employment age, but he also had a slight physical handicap in one leg. The war, however, absorbed most of the available, able-bodied young men and the warden service was fortunate enough to acquire the services of Hubert Green almost by default.

Before coming to Banff Mr. Green had already led a diverse and interesting life. He was born in 1886 in Paris of a Scottish father and a French-Basque mother. He grew up in England and came to Canada in 1905, joining the Royal Northwest Mounted Police in 1907. He served with the police for 25 years before retiring in 1932. It was during his police service that he first became interested in wildlife and conservation. Green spent the majority of his service in the vicinity of Riding Mountain National Park, and there met and developed a friendship with Grey Owe.

Grey Owl had a forceful influence on Green, turning his interest in wildlife and conservation into much more than a hobby. In 1924 Green began writing articles on natural history for magazines under the pen-name of 'Tony Lascelles'. He became a regular contribution to several outdoors magazines, publishing at least 130 articles and stories and receiving the Manitoba Natural History Society Medal.

In 1937 Green moved to Banff to continue his writing and wildlife studies. With the outbreak of World War II he offered his services to the Parks Department and was hired as Special Wildlife Warden for the Banff District. His inquiring and energetic mind had soon initiated a number of studies to improve the state of knowledge about the park's wildlife. Many of his reports constituted the first attempts since park establishment to comprehensively study single species. Some examples of his work include:

1944 A preliminary investigation of the beaver of Banff district
1946 The elk of Banff National Park
1949 The bighorn sheep of Banff National Park
1951 The wolves of Banff National Park
1951 Occurrence, distribution and population of mammals, Banff National Park
1955 The moose of Banff National Park
1955 Notes on the elk of Banff National Park
1955 Notes on the wolves of Banff National Park

In addition to these and other long-term studies of Banff's wildlife, Green was the first to address the problem of standardization of data collection. Prior to the 1940's wardens recorded wildlife in their daily work diaries, often in such general terms that later workers were unable to use the data. In order to ensure that wildlife sightings were recorded in a consistent manner with exact location, number, habitat and other useful information, Green organized the "Wardens Wildlife Card" system. This ultimately evolved into the current computerized system of recording wildlife data (Stelfox et al. 1977).

During the 1940's there was strong pressure on Parks to kill predatory animals, and Green was actively involved in the argument against predator control. He identified garbage management as the major problem in bear management and was far ahead of his contemporaries in his understanding of the complexities of the relationships of wildlife with their environments.

Green initiated the first interpretive programme in Banff National Parks. By 1944 he was feeding beavers aspen cuttings at Vermilion Lakes on a regular basis and explaining beaver behaviour to 25 or 30 tourists per night.

Green was a strong proponent of the idea that National Parks should have resident biologists on staff in order to conduct long-term, in-depth studies of park wildlife populations. When Ian McTaggart Cowan spent only five months in the field to determine the distribution, seasonal movement, numerical status, condition and interspecific relationships of carnivores and ruminants (Cowan 1943), Green was not impressed:

> "How any one individual can acquire a year to year knowledge of wildlife, its inter-related problems of so large an area, is more than the imagination can conceive. One can only assume that osmosis, divine revelation and the use of a crystal ball play an active part... "
>
> (H. Green correspondence, AOCR)

One of the bitter pills of Green's retirement in 1956 was that he was not replaced by another wildlife specialist and not until much later – in the late 1960s and 1970s – would Parks begin more comprehensive wildlife studies. Writing from retirement Green said:

> "What the Banff National Park (and other National Parks) urgently require is the services of a competent resident biologist with more field than classroom experience. Only by such an appointment will an understanding of park wildlife be... acquired."
>
> (H. Green correspondence AOCR)

After retiring, Hubert Green continued to lobby for conservation in Parks and wrote many letters to newspapers and magazines protesting such things as black bear destruction and habitat loss to campgrounds and roads.

Before his death in 1962 Green turned his interests from wildlife and conservation to research into the history of ranching in the West. He was at work on this project when he died in Banff at the age of 76.

2. METHODS

2.1. SAMPLING RATIONALE

Methods were chosen to collect data on the seasonal abundance, distribution and habitat characteristics of all species of mammals, birds, amphibians and reptiles that occur in Banff and Jasper National Park (Tables 2.1 and 2.2). The broad scope of the inventory and the large area involved necessitated a variety of approaches to data collection. The sample methods were fast, simple and quantitative. Some methods were directed specifically at relating wildlife abundance to the ecological land classification. Other methods were used to survey the seasonal movements of selected wildlife, to determine the actual density of some wildlife and to locate less common species. In addition to these primary methods, described below in detail, the wildlife inventory staff lived in Banff and Jasper on a year-round basis and became familiar with the parks and with long-time park residents, ultimately developing insights and understanding that no amount of pure data could provide.

There were three major approaches to gathering wildlife data.

2.1.1 SYSTEMATIC SAMPLING OF ECOSITES

In order to assess the importance of 126 ecosites to each of 300 wildlife species we had to use sample techniques that were fast and simple, yet quantitative. Because of the large area to be inventoried and the probability that wildlife use would vary on the same ecosite from one part of the study area to another, it was necessary to be able to obtain several samples of each ecosite in different parts of both parks.

The major constraints on developing these techniques were:

- Each must sample a small enough area that it will fit entirely within the boundaries of one mapped polygon and one vegetation type. The maximum area sampled, therefore, was 500m x 500m.
- each must require a limited amount of time, effort and equipment, to allow a small staff to sample numerous sites over a wide area and in rugged terrain.
- each must be standardized, easily taught to new staff, and based on the best techniques in the published literature at the time the project was initiated.
- each must be quantitative in order to provide indices of abundance that would be directly comparable from one ecosite to the others.

Table 2.1. The matrix of species groups sampled by each technique, and total sample sizes.

Species group:	*UNGULATES*	*CARNIVORES*	*HARES*	*SQUIRRELS*	*SMALL MAMMALS*	*BIRDS -breeding*	*BIRDS -migrant*	*BIRDS - wintering*	*AMPHIBIANS*	*REPTILES*	*BATS*	*BEAVERS: MUSKRATS*	
Technique:													
Pellet group count	*		*										2472
Ungulate forage plot	*												505
Ungulate survey	*												4 routes
Track count transect	*	*	*	*				*					4,658.5 kmday
Weasel live trapline		*											360 trap-nights
Snap trapline					*								66,000 trap-nights
Pitfall trapline					*								2100 trap-nights
Live-trap grid					*								16
Bat survey											*		14 nights
Call-count transect				*		*							1736
Owl Survey						*			*				12 nights
Breeding bird census plot				*		*							22
Migration survey							*	*					9 routes
Christmas bird count								*					3 areas
Breeding bird survey						*							3 routes
Pond survey						*	*		*			*	
Howling Survey		*											
Random observation	*	*	*	*	*	*	*	*	*	*	*	*	
Literature review	*	*	*	*	*	*	*	*	*	*	*	*	

The techniques which fulfilled these requirements and sampled all the major wildlife species groups were pellet group counts, forage use plots, track count transects, call count transects and snap traplines (Table 2.1). These are described below in detail.

The approach to picking the actual sample locations was subjective. Each year the wildlife inventory crew was provided with a set of 1:50,000 or 1:66,000 air photos of their study area with ecosites delineated by the land inventory crew who had sampled the area the year previously. The wildlife crew then attempted to visit each major valley in the study area at least once during the June-July call-count transect season, once during the July-September snap trapline season, and once during the winter.

Camps were located at warden patrol cabins where possible or near complexes of ecosites when cabins were not available. From each camp, with from one to three

Table 2.2. The matrix of wildlife information provided by each technique.

Wildlife information: / *Technique:*	STATUS AND DISTRIBUTION	ECOSITE IMPORTANCE*	SEASONAL HABITAT USE	SEASONAL MIGRATIONS	POPULATION STRUCTURE; PRODUCTIVITY	MORTALITY	PREDATION	MANAGEMENT	ECOLOGY	FOOD HABITS
Pellet group count	*	*	*							*
Ungulate forage plot		*								
Ungulate survey	*		*	*	*				*	
Track count transect	*	*	*						*	
Weasel live trapline	*									
Snap trapline	*	*			*					
Pitfall trapline	*				*					
Live-trap grid					*					
Bat survey	*									
Call-count transect	*	*	*							
Owl survey	*									
Breeding bird census plot					*					
Migration survey	*		*	*					*	
Christmas bird count	*		*	*						
Breeding bird survey	*			*						
Pond survey	*				*				*	
Howling survey	*									
Random observation	*	*	*	*	*	*	*	*	*	*
Literature review	*		*	*	*	*	*	*	*	*

(Ecosite importance is assessed to some extent by all methods but is directly assessed by those indicated above)

inventory staff and a variable number of volunteers, attempts were made to sample as many different ecosites as possible in 2 or 3 days, before moving to another camp location.

In 1979 a preliminary assessment of our sampling indicated that certain widespread and accessible ecosites had been over-sampled and certain others had been

under-sampled. Consequently, the location of field camps in 1979 and 1980 was partly influenced by proximity to ecosites that still required sampling.

The year was divided into three field seasons:

June 1 to July 15.
During this season the emphasis was on covering the whole study area at least once and conducting call-count transects in as wide a variety of ecosites as possible. The goal was for each staff person to conduct at least 90 transects during this period. Since transects could only be conducted in the early morning, the rest of the day was devoted to pellet group counts, forage use plots, and collection of random data.

July 16 to September 15.
During this season the entire study area was again covered at least once for the purpose of conducting snap traplines and pitfall trapping. Each staff person tried to conduct at least 20 snap traplines and 1 to 5 pitfall traplines. Pellet group counts, forage use plots and random data were gathered throughout this period.

November 15 to March 15.
During this season the emphasis was on conducting track count transects and collecting random data throughout the study area.

The main criteria for locating any of these sample types were that they had to fall entirely within the boundaries of one ecosite and one vegetation type. In some complex ecosites such as heavily gullied slopes or alluvial or colluvial areas, where vegetation was heterogeneous, this was not possible and the sample was considered to have been collected in the most prevalent vegetation type at that site. No attempt was made to sample only sites which fit the central concept of the ecosite; the landscape was sampled as mapped.

The conceptual basis of most ecosites were revised by the land inventory team during the final year when their field data were analyzed in depth. When the final revised maps were prepared by the land inventory team in September 1981, all samples were checked to assure the accuracy of their ecosite designations.

2.1.2 WILDLIFE SAMPLING INDEPENDENT OF ECOSITES

Although ecological land classification lends itself well to the interpretation of wildlife use by most animal species, there are important aspects of the ecology of many species that cannot be assessed by the direct ecosite sampling described above. These aspects involve such things as seasonal changes in distribution and habitat use, particularly by ungulates; critical habitats related to life cycle events such as breeding, nesting and denning; bird migration; and population characteristics of some species (Table 2.2).

To assess these aspects of wildlife ecology it was necessary to devise sampling methods that were somewhat less suited to the primary goal of assessing wildlife use of and abundance on ecosites. Such methods, described below in greater detail, included roadside surveys of ungulates, bird migration surveys, howling surveys, owl surveys, bat surveys, Christmas bird counts, amphibian surveys and live trapping. Although all data collected by these methods were referenced to ecosite and vegetation type whenever possible, no attempt was made to systematically sample all ecosites by any one of these methods.

2.1.3 REVIEW OF LITERATURE, DATA BANKS AND PARK FILES

It was necessary to assess the amount of change to which wildlife populations had been subjected during recorded history in order to view their present status and distribution in the context of on-going processes. The history of landscape change, park management and population increases and declines all influence the present wildlife picture and potential management options.

It was also necessary to review published literature to relate park wildlife populations to those in other areas, to gather species-specific information on productivity, food habits, natural history and mortality, and to review and assess various approaches to management.

Major data sources are described below.

Park wildlife observation cards

These cards were filled out primarily by park wardens but also by park naturalists and other staff, starting in the late 1940's. Since 1976 wildlife cards have been in a computer format devised by Stelfox et al (1977) and are accessible in the CANSIS computer in Ottawa. Prior to 1976 wildlife cards were in a variety of formats. Canadian Wildlife Service staff (Joe McGillis, Dave Poll, Jayne Coneybeare) transferred the data from these earlier cards into a format compatible with the CANSIS system using the services of KAO and Associates Consulting Ltd. Edmonton. There are 30,000 wildlife cards for which relatively complete data were available now on this system.

Park wildlife observation card data were used to determine some population parameters for ungulates, to delineate the historical distribution and occurrences of all species, and to tally food habit, predation and mortality information.

Park Administration files

Through the cooperation of park staff in Banff and Jasper, Canadian Wildlife Service staff reviewed occurrence reports, wildlife and resource management files, correspondence files and other administrative files. Similar records at the Archives of the Canadian Rockies (Banff) and National Archives (Ottawa) were searched. These files provided information on changes in park policy and wildlife management practices as well as some specific information about populations and mortality factors.

Canadian Wildlife Service reports

Over the years a great deal of research has been conducted in Banff and Jasper by Canadian Wildlife Service. These reports provided data on various aspects of wildlife status, distribution, ecology and management.

Other published reports

Where specific questions needed to be answered to put park wildlife status or management in a broader perspective, Canadian Wildlife Service staff reviewed periodicals and books to locate the required information.

2.2. SAMPLING PROCEDURES

2.2.1 CALL COUNT TRANSECTS

Breeding bird populations were sampled by counting birds along 500 m transects using a modification of the method described by Emlen (1971). The number of individual birds seen and heard and the estimated perpendicular distance of these birds from the transect line were recorded. Every 50 m the observer paused and listened for 0.5 to 2 minutes. Each transect was located in a single ecosite. To reduce the variability in the data due to changes in singing frequency, transects were completed between one half hour before dawn and 9:00 a.m., between June 1 and July 15. During July, the intensity of bird song decreased, and transects usually ended before 8:00 a.m.

In theory, the results of the transect surveys can be used to estimate density (Emlen 1971). A coefficient of detectability (C.D.) must be determined for each species to convert the raw count to a density figure. The C.D. value has two components:

1. the lateral distance conversion corrects for decreasing detectability as birds are further from the observer and thus more difficult to see and hear.
2. the basal detectability adjustment corrects for the proporttion of the population that is not singing, resting incubating eggs and feeding and thus undetectable.

While we were able to calculate the lateral distance conversion we were not able to determine the basal detectability adjustment. Thus we were not able to estimate the actual density of breeding birds using this method, but rather we have calculated an index of relative abundance that allows comparisons to be made between the density of birds on each ecosite.

The lateral distance conversion was calculated using all observations of birds (song, call, visual etc) and varies from species to species depending on their conspicuousness. More individuals of a species with a loud call were heard at a distance of 50–100 m from the observer than species with quiet calls. Over 100 m the number of individuals heard decreased rapidly. The number of individuals was assumed to be random with distance from the observer. The estimated number of birds within 250 m (C.D. 250) was derived by extrapolation from the number heard at near distances. The actual number divided by the estimate produced the conversion. The conversion was estimated for each species using data from all transects.

The density index of birds for a specific ecosite was calculated from the formula:

$$DI = 4N / LDC250 \times T$$

where DI is the density index based on estimated number of birds per 100 hectares, N is the number of birds observed on transects in that ecosite, and T is the number of transects in that ecosite. LDC 250 is the lateral distance conversion for a 250 m distance on either side of the transect.

The density index represents an estimate of the relative abundance of species in various ecosites. The figures are probably an underestimate of breeding population densities. In addition to birds, red squirrels were sampled by this method to get a relative index of abundance on each ecosite.

This method was applied only to territorial species of birds which were recorded more than 20 times on transects (ie. frequently enough to establish coefficients of detectability) and to red squirrels. Very uncommon species, waterfowl, raptors, and

non-territorial flocking birds such as siskins and crossbills could not be sampled by this method.

2.2.2 PELLET GROUP COUNTS

The density of pellet groups was used as the major method to determine the relative importance of each ecosite to ungulates. In addition the pellet densities of varying hares were assessed with this method. It was assumed that pellet group densities would be highest on ecosites in which ungulates spend the greatest amount of time and that they spend the greatest amount of time in the ecosites that are most important to them. This approach does not take into account seasonally critical ranges such as calving and rutting areas which may be more important to an ungulate species than pellet group densities indicate; these types of ranges were assessed by other methods (see below).

Each sample consisted of a count of ungulate pellet groups within 25 quadrates each measuring 2m by 5m spaced 50m apart in 5 rows of 5 quadrates. Pellet groups were classified according to species and season of deposition; summer pellets tend to be congealed, since ungulates are feeding on succulent vegetation at this season, while winter pellets are separate.

From 1978 to 1980 two samples were collected at each site by placing a second set of quadrates between quadrates of the first sample. This modification increased the number of pellet groups that were counted and decreased the time walking between quadrates. From one to three hours were required to obtain the information from 25 quadrates, depending on vegetation density and numbers of pellet groups.

To avoid bias resulting from quadrates placed on an ecotone between ecosites, quadrates were rarely less than 50 m from the boundary between two ecosites. Trails and watercourses were also avoided.

The analysis of these data was simple. The actual counts were multiplied by 40 to give the number of pellet groups per km^2 and the average density was calculated for each ecosite and vegetation type.

Within each quadrat, the number of snowshoe hare pellets were counted in each corner 0.5m by 0.5m of the plot. Thus pellets were counted in 25 m^2 for each sample. These counts were multiplied by 400 to give the density of hare pellets per km^2.

2.2.3 UNGULATE RANGE SURVEYS

At some pellet group sample sites the vegetation was also surveyed. On each 10 m^2 quadrat the six most common plants were noted and their abundance coded as follows:

COVER CODE	PERCENT COVER
1	less than 5%
2	6 - 25%
3	25 - 50%
4	51 - 75%
5	76 - 95%

Any use by ungulates of any plant species within the plot was noted – whether or not the plant species was among the six most common. While year–round use of shrubs and saplings was recorded only recent summer use of forbs and grasses could be determined. Use was coded as follows:

USE CODE	PROPORTION USED
0	0%
1	1 – 25%
2	26 – 44%
3	50 – 100%

The results for each row of 5 quadrants were averaged and the frequency of each code tallied for each ecosite and vegetation type. Latin namesof plants used in the text follow Moss (1959).

2.2.4 SNAP TRAPLINES

This was the main method of assessing relative numbers of cricetid rodents and shrews.

A trapline consisted of 100 "Woodstream Museum Special" traps set in a straight line of 50 stations with two traps per station and 10 m between stations. Each trapline was run for two consecutive nights and checked each morning, for a total of 200 trap nights. Bait was a mixture of peanut butter, bacon fat and oatmeal that was heated together and then cooled.

While the majority of traplines were run in July and August, some lines extended the trapping period from 25 May to 25 September. During this project 330 traplines were run, for a total of 66,000 trap nights. Each trapline was set within a single ecosite and vegetation type. Small mammal occurence on each ecosite and vegetation type was compared by calculating the trapping success corrected for spring traps. The correction was made to allow for the decrease in trapping efficiency which resulted from traps being sprung, either by animals which were caught or by any other cause (eg. heavy rain). It was calculated from Nelson and Clark's (1973) formula:

$$CE = 100A/\ N-S/2$$

where CE is the catch per unit effort, A is the number of animals of each species caught, N is the number of trap nights (usually 200) and S is the number of traps sprung by any cause, including animals caught.

For most specimens, the following data were collected: species, age, sex, reproductive condition, weight and standard body measurements. Many skins were flat–mounted on cardboard cards and skeletons were dried. Specimens were deposited in the National Museum of Canada, Royal Ontario Museum and the Provincial Museum of Alberta.

2.2.5 PITFALL TRAPLINES

This method, although not extensively used (21 traplines), was important in assessing the distribution of shrews, which are rarely caught in snap traps. A trapline usually consisted of 20 traps imbedded in the ground flush with the ground surface at about 10 m intervals and one third filled with water. Traps were fruit juice cans with one end removed (height about 17.5cm and diameter about 10.5cm) which were set for five nights (100 trap nights) and checked daily. All traplines were run in July and August except for one on 19 June and one on 5 September. Trapping success is expressed as the number of captures per 100 traps nights.

2.2.6 WINTER TRACK-COUNT TRANSECTS

Winter mammal activity was assessed through counts of the number of tracks that crossed straight transects of 0.5 km or longer. Each transect was within a single ecosite. While skiing, snowshoeing or walking the transect, the observer recorded the number of tracks of each species that had crossed the transect since the last snowfall. Multiple crossings of red squirrels and varying hare trails were arbitrarily counted as 10 tracks. Animals travelling along the transect line and crossing periodically were only listed once. Any specific activities such as browsing, bedding, scent-marking or predation were noted. Individual trails were occasionally followed to collect scats and to obtain natural history information, which was coded as random observations. The length of the transect was measured by pacing or by estimating distance from air photos where there were recognizable features in the landscape.

Track counts were standardized to the number of tracks per km·day by dividing the total track count by the total distance of transects and the number of days since the last snowfall. Snow depths were recorded with the aid of calibrated ski poles. At least 3 snow depth measurements were taken at each transect and the average depth recorded.

In addition, birds were recorded on most transects and the number of individual birds per km was calculated for each species. Since few birds are common in the winter, the abundance of birds in each ecosite could only be assessed for a few species.

2.2.7 BAT SURVEYS

Bats were surveyed by four methods: tuttle traps, mist nets, ultrasonic bat detectors and random searches of potential roost sites.

A tuttle trap is a collapsible trap consisting of a frame supporting two ranks of vertical monofilament lines and a collecting bag (Tuttle 1974; Tidemann and Woodside 1978). Two traps were used unsuccessfully for five nights in August 1980.

Mist nets, 9m long with 38mm black mesh, were used to catch bats in the summers of 1977 and 1980. They were typically set over or adjacent to water courses at dusk and left up until midnight.

Two kinds of bat detecting equipment were used to monitor bat echolocation calls. A broadband microphone (10 to 200khg) with a zero-crossing period meter connected to a portable oscilloscope (Non Linear System MS15, Non Linear Systems Inc., Del Mar, California) provided a visual representation of the pattern of frequency change over time

of bat calls (Fenton and Bell 1981). The visual image allowed identification of bats to species. The second type of equipment was a QMC Mini Bat Detector (QMC Instruments Ltd., 229 Mile End Road, London, England, E14AA), tuneable from 10 to 180 khz, which translates the ultrasonic bat calls into audible clicks. Only the Hoary Bat can be identified with certainty with the QMC Mini Bat Detector. These instruments were used in May and August 1980 in Banff and Jasper.

2.2.8 OWL SURVEYS

Unstructured surveys of the major valley systems of Jasper were conducted during April and May 1980, to determine which species of owls were present and their relative abundance. Surveys were conducted by canoe, foot, bicycle and motor vehicle with frequent listening stops to cover as much area as possible. Surveys were conducted on clear moonlit nights (full moon was 30 April) and began at sunset and lasted until midnight. All owls and other wildlife seen or heard were recorded on wildlife observation sheets. Because of the low densities of owls and the short season during which most species are vocal, systematic sampling of all ecosites and vegetation types was not possible.

Dates and locations of owl surveys are listed below:

26 April	by foot from Palisade Ranch to Devona Road
27 April	by foot from Old Fort Point to the Valley of Lakes.
28 April	by canoe from Old Fort Point along the Athabasca River to the Mile 12 bridge.
29 April	by canoe from Mile 12 bridge along the Athabasca River to the Jasper Lake outlet
30 April	by canoe from Jasper Lake outlet along the Athabasca River to the east boundary
02 May	by bicycle from Maligne Lake to Sixth Bridge
03 May	by foot from Smoky River District cabin along the North Boundary trail 4 km.
04 May	by foot from Smoky River District cabin along the North Boundary trail 5 km.
05 May	by foot from Southesk patrol cabin along the Brazeau River trail 3 km.
05 May	by foot from Arete patrol cabin along the Brazeau River trail 3 km.
06 May	by foot from Isaac Creek patrol cabin along the Brazeau River trail 5 km.

2.2.9 AMPHIBIAN AND REPTILE SURVEYS

Amphibian surveys were conducted from late spring to early summer. Ponds, lakes, sloughs, marshes and rivers were visited at various times thoughout the day. Any visible evidence of breeding such as egg masses, larvae, tadpoles or vocalizations were recorded. Surveys were conducted by wading or by canoe. Rocks and logs in the vicinity of lakes, ponds, marshes and sloughs were overturned to look for salamanders.

Surveys for snakes (the only reptile found in Banff and Jasper), involved hiking in various habitats, overturning logs and looking for hibernacula. Throughout the summer, random observations of amphibians and reptiles were also recorded.

2.2.10 HOWLING

"Spot" howls and unstructured howling surveys were conducted to a limited extent to determine presence or absence of wolves and coyotes in selected watersheds. Simulated howling was conducted from from most backcountry camps. Two howling surveys were conducted along the Cascade Fire Road from Scotch Camp meadows to the Flint's Park turnoff. One survey was done in July, the other in September 1979. Howling was done adjacent to open areas along the road. A similar survey was conducted in September 1979 along the same road from Scotch Camp to the eastern boundry near the Ya-ha Tinda Ranch.

2.2.11 SPRING MIGRATION SURVEY

The spring migration survey is a modification of the Breeding Bird Population Surveys (Erskine 1978). The surveys were conducted from March to June along roads. The observer spent three minutes at each of 50 stops and recorded all birds heard or seen. Stops were located at 0.5 mi (0.5 km) intervals along 24.5 mi (39 km) of highway. Each route had a standard starting point, was driven in one direction only, always commenced 30 minutes before local sunrise, and lasted about 4 hours. Most routes were surveyed twice per week during the spring migration period, by up to 3 different observers. Observer variability was reduced by conducting annual training surveys with all observers participating.

There were four such routes:

1. Highway 1A from the trans Canada Highway at the 5-mile bridge, north to Baker Creek
2. Bow Summit Survey - Banff-Jasper Highway from Herbert Lake to Bow Summit
3. Athabasca Survey - Jasper-Banff Highway from Becker's Bungalows south to the most southerly picnic site on the Athabasca River
4. Maligne Survey - from Maligne Canyon to the second parking lot at Maligne Lake

In addition three "official" routes that were part of the Canadian Wildlife Service national program were conducted some years:

1. Exshaw - from Seebe to Spray Reservoir via 1A highway and Canmore
2. Bow Summit Survey - same as 2 above
3. Sunwapta Falls Survey - from 10 km south of Sunwapta Falls north past Athabasca Falls on highway 93A

2.2.12 WATERFOWL MIGRATION SURVEYS

Spring and autumn waterfowl migrations were monitored by standardized surveys in each of Banff and Jasper. The Banff route consisted of 24 stops at wetlands in the Bow valley, including Vermilion Lakes, Cave and Basin, Johnston Lake and Lake Minnewanka. The Jasper route consisted of 28 stops along the Yellowhead highway from the Jasper dump to Pocahontas Ponds. The waterfowl surveys were conducted twice weekly in spring and autumn.

2.2.13 AUTUMN MIGRATION SURVEY

Since few birds sing in autumn migrants cannot be surveyed in the same manner as in spring. Two routes were walked and all birds seen or heard were recorded. The Banff route followed the railroad tracks from the 5-mile bridge to the Canadian Wildlife Service Laboratory east of Banff townsite, a distance of 8 km, requiring 4 hours to complete. The Jasper route followed the trail from highway 93 to Old Fort Point via Five Lakes, a distance of 10 km, requiring 3.5 hours to complete. These routes were surveyed twice weekly during one autumn each.

2.2.14 UNGULATE SURVEYS

Warden files and Canadian Wildlife Service reports indicated that some areas of the parks adjacent to the highways were heavily used by ungulates at various times of year. Surveys of four of these areas were undertaken from the road, as follows:

1. from Mt. Wilson to Parkers Ridge along hwy 93.
2. from Old Fort Point to the south end of Mt. Kerkeslin, also along hwy 93.
3. the slopes and valleys adjacent to the Cascade Fire Road.
4. the Athabasca Valley east of Jasper along hwy 16.

These surveys were conducted approximately weekly throughout the year except the Cascade and Mt. Wilson surveys which were surveyed less frequently in winter.

A series of survey stops were established on each route and all terrain visible from each stop was scanned with binoculars and a variable 20 to 40x spotting scope. Elevation, U.T.M. grid reference, ecosite and vegetation type were recorded for each ungulate or group of ungulates sighted. Each animal was classified according to age and sex whenever possible.

These surveys provided information on ungulate use of ecosites, vegetation types and seasonal ranges. These data were used to determine the seasonal and geographical distribution of ungulates along the ranges visible from the survey routes, as well as age-sex ratios and herd productivity.

A detailed description of each route is presented in section 4.2.

Table 2.3. Talbot bird migration survey route: road log.

Stop #:	*Distance from last stop: kms.*	*miles*	*Location:*
-			Jasper sanitary landfill site
1			Snaring Lake
2	0.7	0.45	Athabasca River floodplain
3	.6	0.4	Snaring River Bridge
4	2.3	1.45	Athabasca River (backwater 20 metres from hwy)
5	1.5	0.9	Athabasca River (mile 12 bridge)
6	0.2	0.1	Athabasca River (backwater to left of highway)
7	0.4	0.25	Cold Sulfur Spring Plague
8	0.2	0.1	Ponds on either side of highway
9	0.5	0.3	Ponds adjacent mile 18 signpost
10	0.4	0.25	Ponds
11	3.4	2.1	Edna Lake-south end
12	0.3	0.2	Edna Lake and Jasper Lake
13	0.4	0.25	Edna Lake and Jasper Lake
14	1.9	1.15	Talbot Lake
15	1.1	0.7	Talbot Lake (old dock)
16	0.2	0.1	Talbot Lake (small ponds on either side)
17	0.2	0.1	Talbot Lake
18	0.6	0.4	Talbot Lake (picnic site)
19	0.8	0.5	Talbot Lake (big bend in highway)
20	0.5	0.3	Talbot Lake
21	0.8	0.5	Talbot Lake
22	0.3	0.2	Ponds at north end of Talbot Lake
23	1.1	0.7	Jasper Lake outlet at Jasper House monument
24	0.2	0.1	Rocky River bridge
25	2.9	1.8	Athabasca River (Disaster Point)
26	4.4	2.6	Pocahontas Ponds
27	0.1	0.2	Pocahontas Ponds
28	1.3	0.8	Pond north of Pocahontas to right of highway

2.2.15 BREEDING BIRD CENSUS PLOTS

Twenty-two breeding bird census plots were established in Banff and Jasper National Parks from 1975 to 1979. Census plots ranged in size from 10.0 to 80.0 hectares and all but one were marked with survey tape at fifty metre intervals. Thirteen census plots are permanently marked with numbered metal markers or on townsite and campground maps to enable future investigators to sample them and monitor changes in bird populations.

Census plots were situated close to roads to allow easy access; in patches of vegetation sufficiently extensive that no major vegetation boundaries fell within the census plot boundaries; and in as many as possible of the major vegetation types and ecoregions of Banff and Jasper. In addition, four census plots were laid out in unique, disturbed

Table 2.4. Vermilion-Minnewanka migration survey route: road log.

(This survey is conducted by vehicle along Vermilion Lakes, Cave and Basin, Tunnel Mountain and Lake Minnewanka drives. Birds seen while driving the latter two drives were also recorded.)

Stop #:	*Distance from last stop: kms.*	*miles*	*Location:*
1			First Vermilion Lake
2	0.4	.3	Channel between first and second
3	0.6	.4	Second Vermilion Lake
4	0.3	.2	Beaver Ponds
5	0.5	.3	Middle Ponds
6	1.3	.1	Third Vermilion Lake
7	0.7	.4	Pond near end of Vermilion Lakes drive
8	6.0	3.7	Bow River boat dock
9	2.0	1.2	Horse stables near Banff recreation ground
10	0.8	.5	Cave and Basin marsh - walk to Bow River
11	0.5	.3	Cave and Basin marsh at inflow
12	2.7	1.7	200 block - Otter Street - Tunnel Mountain drive to Lake Minnewanka drive
13	7.2	4.5	Johnson Lake
14	4.9	3.1	Two-Jack Lake
15	1.2	.8	Lake Minnewanka
16	6.6	4.1	Banff landfill

habitats such as the Mushroom Patch area in Jasper, Jaspertownsite and Tunnel Mountain Campground in Banff.

Sampling was conducted according to the methods outlined by Hall (1964). Census plot lines were walked by a single observer and all bird observations were marked on a map of the census plot. Wherever possible attempts were made to indicate whether birds had changed position or whether a new mark represented a different bird. Census plots were sampled at varying times of day, between June 1 and July 20. Although Hall recommends a minimum sample size of eight surveys per census plot, our plots were considered a lower priority than call count transects which were also conducted during the same period. Consequently, we attempted to sample each census plot at least six times during each breeding season and some plots were not adequately sampled. To avoid misleading comparisons the reader should make note of the sample sizes when comparing results from various census plots.

At the conclusion of each field season composite maps were drawn of each census plot showing single-species distributions. Clusters of sightings were interpreted as representing individual territories, with sightings of singing males being given highest priority (the William's Spot mapping method; Robbins 1970). Nests on the plot were considered to represent one territorial pair of birds.

Vegetation analyses of the census plots were conducted during 1979 using a modification of the tenth-acre circle method described by James and Shugart (1970). Our sampling technique deviated from theirs in that we counted all trees over 2 m in height

as trees, regardless of their d.b.h. (diameter at breast height). In addition, we counted shrub stems by species, rather than lumping all shrubs together, since the habitats sampled in Banff and Jasper consistently contain only a few of the six common tree species of our region, while shrub species are more variable and more important in defining habitats. Four census plots in the Icefields area of Jasper were not sampled for vegetation since their markers had disappeared since 1977.

2.2.16 LIVE TRAP GRIDS

Small Mammals

Live trapping gave actual densities of small mammals rather than a relative index of density such as provided by snap trapping.

Live-trapping grids consisted of 100 Sherman traps baited with peanut butter or sunflower seeds. Traps were set at 10m intervals on ten lines separated by 10m (area of 1 ha) and were operated for five nights. Each grid was located in one ecosite and one vegetation types. Captured animals were removed from traps in the morning and, when high numbers of animals were being captured, in the evening. Animals were identified with numbered ear tags (fingerling tags). Species, identification number and capture location were recorded at each capture. Body weight, sex and reproductive condition were recorded on some census plots.

The Peterson Index was used to estimate densities.

Weasels

Wooden live traps were used to catch weasels. The purpose was to determine the relative abundance of long-tailed and short-tailed weasels and the distribution of mink. The traps were baited with kippers, sardines, raspberry jam and dead mice in various combinations. During October 1977, traps were set for 222 trap nights around the Vermilion Lakes and the Cave and Basin Swamp. Other trapping was conducted in the lower Spray valley (100 trap nights), North Saskatchewan valley (8 trap nights) and Athabasca valley (50 trap nights).

2.2.17 CHRISTMAS BIRD COUNTS

The Bow Valley Naturalists have conducted Christmas bird counts in the Banff-Canmore area since 1974 and three additional surveys were conducted from 1960 to 1962 by members of the Calgary Bird Club. These counts are conducted by as many naturalists as are available within a single day within a specified two-week period at Christmas (National Audubon Society, New York). The count area falls within a 15 mi (24 km) diameter circle including the Vermilion Lakes and Canmore. Since 1975 the results have been published in American Birds. In Jasper Christmas bird counts were conducted by inventory staff and park naturalists in 1978 and 1979 within a 15 mi (24 km) circle centred on the townsite.

2.2.18 RANDOM OBSERVATIONS

The collection of random observations was recognized as a sample method. No attempt, however, was made to standardize the way in which random or spot observations were collected. Random observations included aquatic surveys by canoe, herptile surveys, road mortality of small wildlife (the warden service reports large species), wildife incidentally observed during formal surveys and other casual observations.

All such observations were coded onto a computer sheet with UTM coordinates, vegetation type and ecosite. Random observations were computer-sorted to allow assessments of the occurrence of species on each ecosite and vegetation type, the chronology of species distribution and any reproductive and mortality information.

These observations are to be converted to the warden card format and added to the CANSIS file.

For some species (eg. hoary marmot, pika, beaver, muskrat and several bird species) random sightings and non-systematic searches are the only data base. Random observations collected during the inventory were used to prepare distribution maps of selected species in the species accounts (section 3).

2.3. DATA ANALYSIS

2.3.1 ABUNDANCE RATINGS

One of the objectives of the wildlife inventory is to determine the distribution of wildlife at a scale of 1:50,000. A plot of actual sightings or sign would not accomplish this goal but would only show the location of the observers when they found wildlife. The alternate approach is to identify the important wildlife habitat and then map the habitats. The land inventory provides the map base to show the distribution of habitat as long as the criteria used to identify the ecosites also define wildlife habitats. Most wildlife habitats can be related to one or more ecosites. Some habitats are too small to be identified at a scale of 1:50,000; other habitats are complexes of ecosites which are difficult to identify in a classification system. Consequently there are difficulties relating all wildlife habitats to the ecosites. However many habitats can be readily related to ecosites, and the classification and mapping scheme can illustrate the distribution of these habitats.

Important wildlife habitats are identified by sampling wildlife or their sign on all ecosites and vegetation types and evaluating the results. For each sample type and species the results on each ecosite were ranked as described below and a legend prepared correlating wildlife important rankings with each ecosite (Map Supplement and section 6).

The previously-discussed methods provide data on relative abundance but in numerical form they are difficult to use to compare ecosites. In addition, each method has a different range of numerical values. To simplify the use of the data it has been converted into rankings that allow easy comparisons of ecosites.

2.3.2 ECOSITE RANKINGS

The data from the primary sample methods are computer-manipulated to produce an average quantity for each ecosite. The quantities for the ecosites are then ranked as none, low, medium, high and very high to compare the relative degree of use of each ecosite. The ranking is determined by dividing the non-zero quantities into three equal sets based on their values. The set of ecosites having the lowest values are considered to be of low importance to the species in question. The set having the most average values are considered moderately important, and the set comprised of ecosites having the highest values are considered highly important. The five or ten ecosites having the highest values are considered very highly important.

Thus, for species, the importance of an ecosite is considered to be directly comparable to the measured relative abundance of that species on the ecosite. For groups of species (eg. small mammal associations and bird communities; section 5) the total of rankings of all species is combined with the number of species to evaluate the importance of the ecosites.

Vegetation types were similarly ranked as to their importance to wildlife. Important habitats are considered to be the highly ranked ecosites and vegetation types. Critical habitats are the very highly ranked ecosites and vegetation types, in addition to habitats with special functions to wildlife (eg. denning, calving, staging, etc.). It should be borne in mind that critical areas may be site-specific and hence not predictable on the basis of habitat generalities. Any attempt to assess the importance of a single site to wildlife must be supported by actual field observations on that site.

This approach to ranking ecosites assumes that all ecosites were sampled equally, and that animals and their sign are equally detectable on each ecosite. While these assumptions are true in many instances, they do not always apply. For example in winter some moose use wetlands where their droppings end up in standing water the following spring, and are not detected in pellet group counts. All rankings were reviewed subjectively and some were adjusted because of sampling biases.

An additional method of ranking ecosites was devised for lynx, coyotes, wolves and cougars. Relatively few tracks of these species were recorded on track transects, yielding insufficient data to rank their occurrence on each ecosite. There are, however, considerable data on the distribution of ungulates and other prey on each ecosite. From studies of the food habits of coyote (Bowen 1978), wolf (Carbyn 1974b) and cougar (Robinette et al. 1959) the proportion of each prey species in the predators' diet was determined and used as weighting factors to determine the potential importance of each ecosite to the predator (Table 2.5). For each ecosite, the rank for each prey species was assigned a value (0 for none, 1 for low, 2 for medium, 3 for high and 4 for very high). The following formula was used to derive values:

Ecosite value = (prey species' rank value) X (proportion of that species in the predator's diet) summed for all prey

For lynx, the ecosite rankings of snowshoe hare were used because of the paucity of tracking data and the dependence of lynx on hare. These values were then ranked similarly to the results from other sample methods; the lowest third were low, the next third medium, the largest third high and the top five very high. For coyote and lynx

Table 2.5. The proportion of prey in the diets of coyote, wolf and cougar*
* Derived from Bowen 1978, Carbyn 1974b and Robinette et al. 1959

	Coyote		*Wolf*		*Cougar*
	Winter	Summer	Winter	Summer	
Varying Hare	7	1	0	0	0
Col. Gr. Squirrel	0	13	0	0	0
Microtine voles	16	11	0	0	0
Deer	26	22	50	30	29
Moose	6	2	8	8	0
Elk	30	25	25	46	17
Bighorn Sheep	4	2	3	3	15

these ranks compared well to the limited tracking information available.

2.3.3 BIRD ABUNDANCE

Abundance rankings for birds are based on three data sets: migration surveys, call-count transects and winter track count transects.

Migration surveys were used to rank the abundance of migrant birds (Table 2.6). The peak numbers recorded during spring and autumn surveys in both parks are comparable to the number of birds expected during those seasons. Surveys were not corrected for any biases in habitat coverage that resulted from the surveys being conducted from roads. Such a refinement would not be likely to alter the abundance ratings for many species.

The density indices derived from call-count transects were used to rank bird abundance during the breeding season. Density indices were calculated for each ecosite and vegetation type, the highest two values for each species being used to rank the species abundance, to avoid single high values based on sampling size biases. The ranking values are an approximate conversion of a scale used in New York, Saskatchewan and elsewhere (Renaud and Renaud 1975). This scale separates values for birds larger or smaller than the common flicker.

To rank winter abundance we used track count transect results, supplemented by Christmas Bird Counts. The values indicate the approximate number a person might see on a 5 km walk in appropriate habitat. When adjusted for area the winter values are less than those for the breeding season.

In addition to the above, random observations were used where species were poorly documented by these sample methods (for example, non-territorial species in the breeding season). When random observations were used the migration scale was used to rank a species' abundance.

Table 2.6. Abundance scales for birds during migration, breeding season and winter.

Abundance Category	*Migration* (# per survey)	*Breeding Season* (density index)		*Winter* (# per 5km.)	
		smaller than flicker	larger than flicker	smaller than flicker	larger than flicker
Abundant	501 +	50-250	10-250	101+	28+
Very Common	101-500	10-49	4-9	26-100	6-25
Common	26-100	4-9	2-3	6-25	2-5
Fairly Common	6-25	2-3	0.5-1	2-5	1*
Uncommon	1-5*	1*	0.01-0.5*	1*	1**
Rare	1-5**	<1*	<0.01*	1**	<1**
Very Rare	<5 ever	<5**	<5**	<5 ever	<5 ever

* more than 5 records per season
** fewer than 5 records per season

Other definitions used in the bird species accounts are:

Spring	= March, April, May
Summer	= June, July
Autumn	= August, September, October
Winter	= November, December, January, February

early	= 1st to 10th (of a month)
mid	= 11th to 20th (of a month)
late	= 21st to 31st (of a month)

Where an ecosite or vegetation type was not sampled, a rank was assigned based on the classification of similar ecosites or vegetation types.

3. SPECIES ACCOUNTS

3.1. AMPHIBIANS AND REPTILES

WESTERN TOAD *Bufo boreas* NOTO

STATUS AND DISTRIBUTION

The Western toad ranges south from southern Alaska to northern California and east from the British Columbia coast to the Rockies. It is the most widespread and frequently encountered amphibian in Alberta's Rocky Mountains, including Banff and Jasper (Figure 3.1, 3.2).

Museum records of this species in Banff date back to 19 August 1914 when specimens were collected at Forty Mile Creek by N.B. Sanson. These were stored at the Banff Museum. In Jasper the earliest specimen was collected on 21 July 1943 by Lister and Moore, and stored at the University of Alberta, Museum of Zoology.

HABITAT

This species has been found in the montane, lower subalpine and upper subalpine ecoregions. The Western toad is not confined to any particular habitat type except during the breeding season when they require standing water.

LIFE HISTORY

Western toads are terrestrial except during the breeding season, which in Banff and Jasper extends from 5 May to 8 June. At this time they are found in the vicinity of shallow ponds, lakes, backwaters and flood-pools of streams. Egg masses are deposited in long strings and are often wrapped around submerged vegetation. In Banff and Jasper these strings were found within 2 to 15 cm (n=4, m=7.5cm) of the surface in water.

In Banff and Jasper larvae are seen as early as 7 June and as late as 11 August. The tadpoles hatch and rapidly develop into small toads, usually in July or August (Hodge 1976).

Figure 3.1. Distribution of reptile and amphibian observations in Banff.

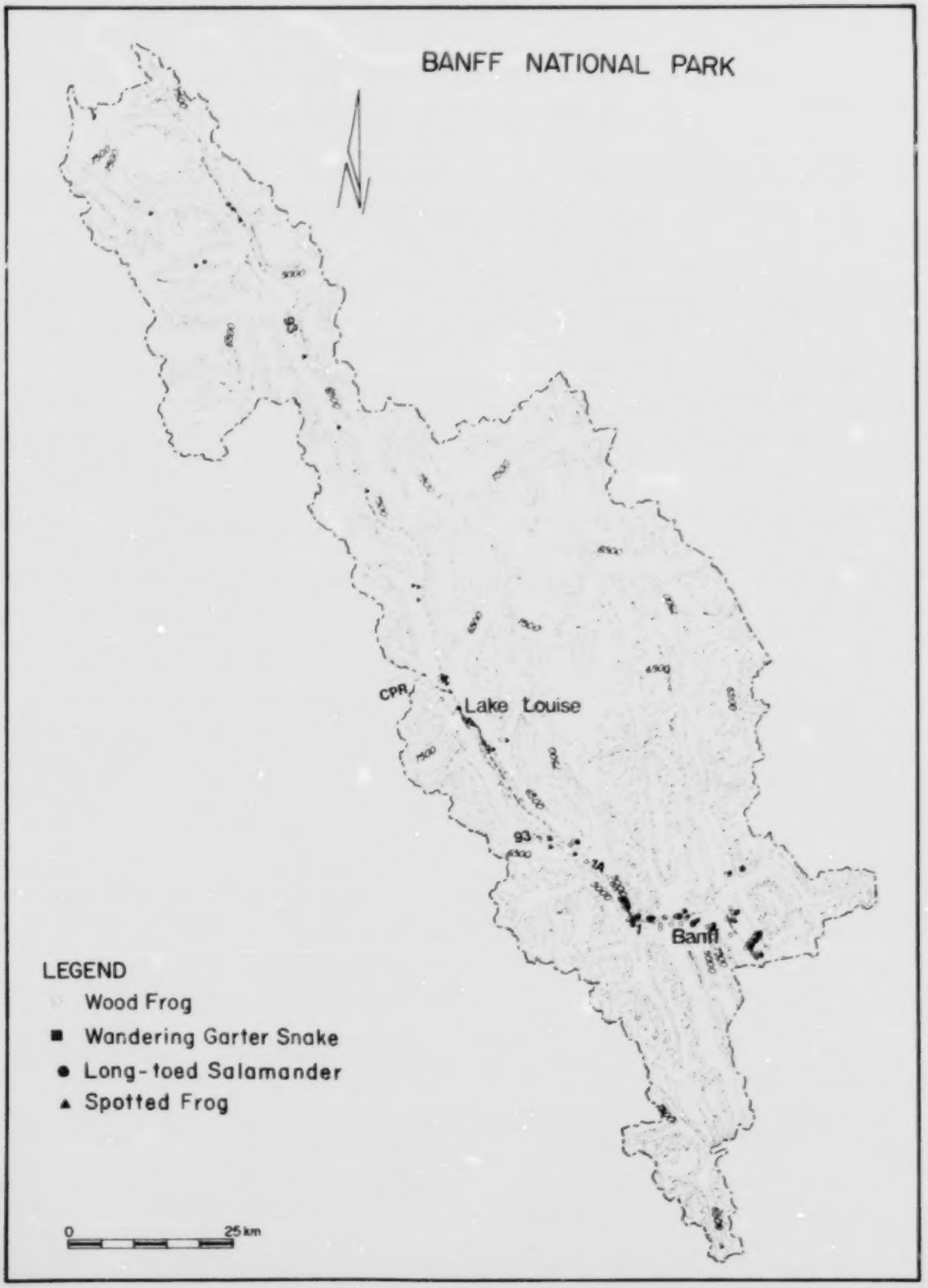
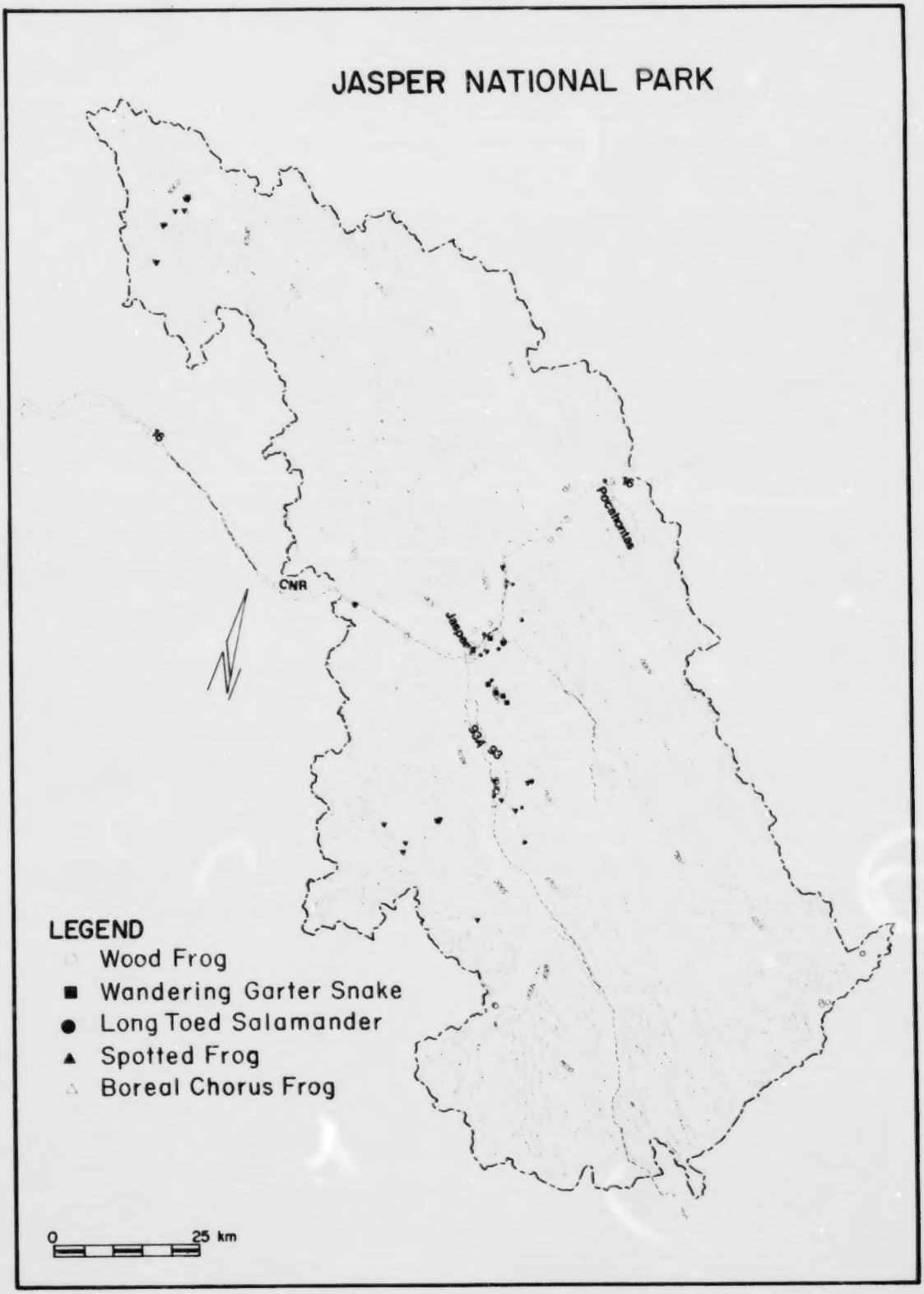


Figure 3.2. Distribution of reptile and amphibian observations in Jasper.



The call of the male is a high pitched trill and is heard from 4 May to 27 June in Banff and Jasper.

WOOD FROG *Rana sylvatica* **WOFR**

STATUS AND DISTRIBUTION

The Wood frog is widespread and abundant throughout Canada. It is the only amphibian known to occur north of the arctic circle in the western hemisphere (Martof 1970).

This species is uncommon in both parks; however, it is locally abundant in suitable habitats (Figure 3.1, 3.2). In Banff most breeding sites are in the Bow River valley downstream of Herbert Lake, but two sightings of four adults were recorded in Baker Creek. In Jasper Wood frogs have been seen in the Southesk River, Snake Indian River, Miette River, lower Brazeau River, Smoky River and Whirlpool River valleys. The majority of records were in the Athabasca River valley downstream of Leach Lake.

Most breeding sites have up to twenty males calling, but on 10 May 1978 at least 50 were calling at Muleshoe and 100 near highway 1A 2.5 km west of Five Mile bridge. These two sites (UTM NG895702 and NG913691) have exceptional concentrations of this species.

Museum records of the Wood frog in Banff date back to 1 July 1914 when specimens were collected at the recreation grounds by J.W. Hill. These specimens are at the Banff Museum. Specimens were collected on 21 July 1943 at Pyramid Lake in Jasper by W. Rowan and were stored at the University of Alberta, Museum of Zoology.

HABITAT

The Wood frog is terrestrial throughout most of the year, and may be found in grasslands, open forests or moist woods, near water. It occurs most commonly in the montane ecoregion but also in the lower subalpine ecoregion. In Banff and Jasper Wood frogs range in elevation from 1000 to 1600 m above sea level.

Wood frogs spawn in slow or standing water with gently-sloping shorelines and bottoms. In Banff and Jasper 70% of the spawning sites surveyed were characterized by muddy bottoms.

LIFE HISTORY

The breeding dates for Banff and Jasper are from 26 April to 27 May. Males were heard calling from 22 April to 21 June, with one additional record on 11 August.

Globular egg masses are deposited below the surface of the water and are often attached to submerged vegetation. In Banff and Jasper there is a range of 100 to 400 eggs per mass (n=10), whereas Martof (1970) has found up to 2500 eggs per mass. The eggs hatch in approximately 10 to 14 days, and the tadpoles transform in 40 to 90 days after hatching (Cochran and Goin 1970).

The first tadpoles were observed in Banff and Jasper on 16 May, and young were seen newly metamorphosed as late as 21 August.

The call of the Wood frog is distinctive, sounding like a quacking duck.

MANAGEMENT CONSIDERATIONS

Pollution or disturbance of small ponds in the Bow and Athabasca valleys could affect Wood frog populations. Dumping rip-rap in sloughs and marshes for road or railbed construction, especially, would harm local populations of this species.

Some Wood frog spawning sites are easily accessible, such as Vermilion Lakes and Pocahontas Ponds, and could be of interpretive value.

SPOTTED FROG *Rana pretiosa* **SPFR**

STATUS AND DISTRIBUTION

The Spotted frog ranges from southeast Alaska, south through British Columbia and western Alberta (Wright and Wright 1949). It occurs from sea level at the coast of British Columbia, to 2000 m elevation in the Rocky Mountains of Alberta.

This species is uncommon in both Banff and Jasper, but it occurs more frequently in Banff (Figure 3.1, 3.2). Sightings have been made in the Alexandra River, North Saskatchewan River, Mistaya River, upper Bow River, Pipestone River, Baker Creek, Altrude Creek and Spray valleys and at Vermilion Lakes and Anthracite in Banff. In Jasper all sightings are from the Athabasca River, Astoria River, Miette River, Smoky River and Whirlpool River valleys.

Museum records of this species in Banff date back to 1914 when specimens were collected at the recreation grounds and the Cave and Basin marsh by N.B. Sanson. These specimens are recorded in the Banff Museum. In Jasper specimens were collected in July 1944 at Buck Lake by Julian Rowan and stored at the University of Alberta, Museum of Zoology.

HABITAT

In Banff and Jasper small ponds and river lowlands are preferred spawning sites. Almost (60%) of all Spotted frog sightings are from the lower subalpine ecoregion in ecosites characterized by mesic to hygric moisture regimes. Another 36% of sightings are from alluvial fans and terraces in the montane ecoregion. Only 4% of the sightings are from the upper subalpine ecoregion. The elevational range of the Spotted frog in Banff and Jasper is from 1000 to 2000 m above sea level.

LIFE HISTORY

The Spotted frog is an aquatic species that is found in the vicinity of permanent water bodies. The earliest recorded emergence in Banff and Jasper is 3 May 1980. This species normally emerges from hibernation during March, or when the air temperature has risen to 13 to 16°C for several days (Morris and Tanner 1969). The temperature of the water under which the frogs hibernate is also important; the water must reach 10-11°C before Spotted frogs are released from hibernation.

The Spotted frog breeds during the month of May in Banff and Jasper with eggs found from 3 May to 27 May. The egg mass is deposited in the shallow open water of ponds, marshes or river lowlands, and is not attached to the vegetation. Hatching time varies from year to year depending upon temperature fluctuations and may range from 7 to 23 days (Morris and Tanner 1969).

The call of the Spotted frog is a series of clicking sounds similar to low-pitched woodpecker drumming. In Banff and Jasper the call has been heard 4 times between 3 May and 12 July.

MANAGEMENT CONSIDERATIONS

Pollution and disturbance of ponds and marshes may detrimentally affect Spotted frog populations. A high concentration of soluble salts in water is believed to retard both the spring emergence of the adults and the growth of larvae (Morris and Tanner 1969). Thus, salting of highways should be minimized on roads adjoining habitat used by Spotted frogs, such as: Highway 1A by McNair Pond, Icefields Parkway near Herbert Lake, and the stretch of Icefields Parkway between Norman and Rampart Creeks.

Draining of ponds impairs breeding of this species. Ditches which drain ponds on the east side of the Banff–Jasper Highway in the Mistaya valley have eliminated breeding sites and will eliminate others as erosion drains other ponds upstream.

BOREAL CHORUS FROG *Pseudacris triseriata maculata* **BOFR**

STATUS AND DISTRIBUTION

The Boreal chorus frog is widespread in Canada. Its range extends from British Columbia east to Ontario and north to Great Bear Lake.

This species is rare in Jasper and has not been recorded in Banff (Figure 3.1, 3.2), although it occurs in Bow Valley Provincial Park, east of Banff (C. Wallis and C. Wershler pers. comm.). In Jasper it is confined to the lower Athabasca River valley between Jasper Lake and the eastern park boundary.

There are no historical records of this species in Banff and Jasper.

HABITAT

The Boreal chorus frog is confined to alluvial floodplains with seasonal flooding in the montane ecoregion downstream from Jasper Lake. Temporary ponds are necessary for spawning. In Banff and Jasper Boreal chorus frogs have only been recorded below 1000 meters elevation in the lower Athabasca River valley. This is the lowest elevation in Banff and Jasper and represents an extension of the boreal region into the Rocky Mountains. These records are all from flooded willow thickets, emergent sedge beds, and white spruce forest on the floodplain of the lower Athabasca River.

LIFE HISTORY

The marshy vicinity of Pocahontas Ponds is a probable breeding site but no egg masses or larvae have been found.

The call of the Boreal chorus frog is distinctive, like the sound of a fingernail running over the teeth of a comb, and as the name implies, this species is rarely heard singly. Up to 20 were heard calling in the vicinity of Pocahontas Ponds from 11 to 15 June 1978.

MANAGEMENT CONSIDERATIONS

As there is only one site in Jasper where this species occurs, (UTM MJ337964 and vicinity), this unique site should be protected from disturbances and unnatural changes in water regime and water quality.

LONG-TOED SALAMANDER *Ambystoma macrodactyum* LOSA

STATUS AND DISTRIBUTION

The Long-toed salamander ranges from southern British Columbia and Vancouver Island east to Alberta. It is one of only two salamander species which occur in Alberta and is restricted to the Rocky Mountains (Salt 1979).

The Long-toed salamander is uncommon in both Banff and Jasper. In Banff this species is known from only 11 breeding sites in the Bow valley south of Eisenhower Junction (Figure 3.1). Ponds north of Eisenhower Junction have not been found to harbour this species. In Jasper there have only been 3 documented sightings of the Long-toed salamander (Figure 3.2). There are undocumented sightings from the Miette valley both at Decoigne and Yellowhead Pass (D. Friedman pers. comm.).

Museum records of this species in Banff date back to 1896 when a specimen was collected at the sanitarium cellar by NB Sanson. Specimens are stored at the Banff Museum. In Jasper the earliest specimen was collected in 1942 at the townsite by W. Cable, and is stored at the University of Alberta Museum of Zoology.

HABITAT

This species occurs in the montane ecoregion, between 1200 and 1430 m above sea level. It occurs most commonly in wetlands and on alluvial fans, aprons or terraces. Small ponds with muddy bottoms and grassy margins, close to forests, are preferred spawning sites.

LIFE HISTORY

The Long-toed salamander is mainly terrestrial except during the breeding season, which in Banff and Jasper extends from 26 April to 31 May. At this time Long-toed salamanders may be found in the vicinity of small ponds.

The Long-toed salamander deposits strands of 1 to 60 eggs (m=8.6, n=40), which are attached to submerged vegetation. Larvae have been seen as late as 27 August.

Adults remain subterranean during the summer and can sometimes be found under logs and rocks.

MANAGEMENT CONSIDERATIONS

Long-toed salamanders are vulnerable to trout depredation of larvae, as they are absent from some ponds that contain trout but that are otherwise suitable. Pilot Pond was locally known as Lizard Lake due to its large numbers of Long-toed salamanders, until trout stocking eliminated them (E. Carleton pers. comm.).

WANDERING GARTER SNAKE *Thamnophis elegans vagrans* **WASN**

STATUS AND DISTRIBUTION

The Wandering garter snake ranges from coastal British Columbia, through the Rocky Mountains in Alberta, to western Saskatchewan (Behler and King 1979).

This species is rare in both Banff and Jasper (Figure 3.1, 3.2). Another species thought to occur in Banff and Jasper is the red-sided garter snake (*T. sictalis parietalis*) (R. Dobson, Banff park naturalist, pers. comm.), however its presence has never been verified. In Banff the majority of sightings of Wandering garter snakes have been in the wetlands associated with the Cave and Basin Hot Springs, which supports the only known hibernaculum.

Nine sightings of 1 to 3 snakes were recorded in this area between April and the end of August. Other sightings of the Wandering garter snake in Banff include a single snake on the railroad bed by the Fenland Trail in May 1968 by D. Cockerton, and 3 snakes at the Ghost Lakes on 28 July 1975 by J. Wolford. In Jasper there have been 6 sightings; 1 at the valley of the Five Lakes on 21 July 1978 (DBD), 3 at the valley of the Five Lakes on 12 May 1980 (RLM) and one at Devona Flats on 1 June 1978 (MAS). There have also been some undocumented sightings on the Pyramid Bench (Tony Pierce, Jasper Interpretive Service, pers. comm.).

Museum records of this species in Banff date back to 1897 when specimens were collected by N.B. Sanson at the Middle Hot Springs Swamp and stored at the Banff Museum. In Jasper the earliest specimen was collected in 1926 at Lake Annette and is stored at the National Museum of Canada.

HABITAT

The Wandering garter snake is restricted to the montane ecoregion. According to Stebbins (1954) this species is terrestrial, inhabiting meadows with tall grasses and clearings with second growth forest. In Banff however, the majority of sightings are in wetlands associated with hot springs. In Jasper all but one sighting were in close proximity to permanent water.

Hibernacula must be in areas that will provide the snakes with a maximum of sunlight and a sufficiently long summer to allow feeding, growth and successful reproduction (W. Roberts, pers. comm.). In Banff and Jasper there are not very many areas that fulfill these requirements. Sites which are physically suitable for hibernacula such as talus slopes do not often have suitable food sources or thermal environments. Although higher altitudes receive large amounts of direct sunlight, they are subjected to cooler temperatures and exposure to cold winds. Montane valleys with frequent flows of mild Pacific air, or localized warm conditions, provide the most favourable environment for garter snakes in the mountains (W. Roberts, pers. comm). In Jasper Wandering garter snakes occur in montane valley bottoms or areas with southern exposures that receive direct sunlight.

Some potentially suitable habitat is not inhabited by snakes as their poor mobility in cold weather and low numbers do not allow dispersal into such areas (W. Roberts pers. comm.).

LIFE HISTORY

Very little is known about this species in Banff and Jasper as there have been only 17 sightings in the past 7 years.

Snakes were seen emerging from a hibernaculum as early as 10 May and have been recorded as late as 23 August.

MANAGEMENT CONSIDERATIONS

The limited distribution of this species in Banff and Jasper and its dependence on habitats of limited occurrence render the protection of known hibernacula and areas of concentration critical for the survival of the species. Cave and Basin staff should be encouraged to protect snakes in the vicinity of the hot springs.

3.2. BIRDS

Bird species accounts are arranged in a standardized format. Each account begins with the accepted common name according to the American Ornithologists Union (AOU) Checklist, the scientific name, and a symbol indicating breeding status.

B	known to breed in Banff and/or Jasper
b	probably breeds, but no nests or young recorded
b?	may breed, based on known range of the species or dubious sightings

Status and distribution are described for each species with the seasonal status indicated in a table beneath each species' name. The terminology used to describe status is based on quantitative measures described in the Methods section above. Status and distribution of the species are described firstly on a broad scale and then on a more park-specific scale. The timing and magnitude of migration are described, with graphs where adequate data exist. If the species has bred in Banff and/or Jasper the earliest dates of nesting, hatching and fledging are given if known. When a Canadian Wildlife Service staff saw a species, the sighting is referenced with the initials of the observer and the initials are shown in the acknowledgements.

The habitat section describes the species' habitat in general terms for all species. For species sampled by call-count transects, the vegetation types having the highest density indices for that species are listed.

The management section describes specific management concerns where these are known. The absence of a management section in a species account does not mean the species has no management needs, only that no non-habitat-related problems have yet been identified.

The abundance and time of occurence of birds is presented in the bird checklist (Van Tighem and Holroyd 1982). In addition two guides to places to birdwatch have been published (Van Tighem and Holroyd 1981, Holroyd and Van Tighem 1982). These publications are available from the parks interpretive and information services.

COMMON LOON *Gavia immer* **(B)** **COLO**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: fairly common resident
Autumn: fairly common migrant
Winter: not recorded

The Common Loon is a circumboreal species which breeds throughout Canada except on the prairies (Godfrey 1966). It nests throughout northern and central Alberta and the Rocky Mountains and their foothills (Salt and Salt 1976).

In Banff and Jasper the Common Loon is restricted in its distribution by the scarcity of sizeable lakes. Although it does not breed on Vermilion Lakes, up to three pairs breed on Talbot Lake and most of the lakes of Jasper's Pyramid bench support a pair of breeding loons (Figure 3.3, 3.4).

Spring migration is during April and May. Peak migration is in early May. Earliest record is 11 April 1979 at Talbot Lake. Maximum recorded count is 19 on 9 May 1979 at Talbot Lake.

Earliest recorded nest is 31 May 1978 at Talbot Lake. Earliest recorded young is 15 June 1969 at Talbot Lake (Loewen 1970).

Autumn migration lasts from August to November. Peak migration is in mid-August. Maximum recorded count is 11 on 29 October 1978 at Talbot Lake. Latest record is 9 November 1978 at Talbot Lake.

HABITAT

The Common Loon occurs primarily in lakes and ponds of the montane and lower subalpine ecoregions. Undisturbed shorelines with herbaceous or shrubby cover are preferred; complex shorelines, small islands and hummocks, and beaver and muskrat lodges provide nesting sites. Common Loons occur regularly only on waterbodies supporting adequate populations of fish.

MANAGEMENT CONSIDERATIONS

The absence of breeding loons from Vermilion Lakes can only be attributed to excessive disturbance by recreationists. That Common Loons can tolerate a low degree of disturbance is evidenced by their presence on Talbot Lake. Protection of shorelines and small islands and continued prohibition of motorboats will ensure the well-being of Banff's and Jasper's loons. Boating and wind-surfing should be discouraged on Talbot Lake and other small or narrow lakes.

Figure 3.3. Distribution of Common Loon observations in Banff.

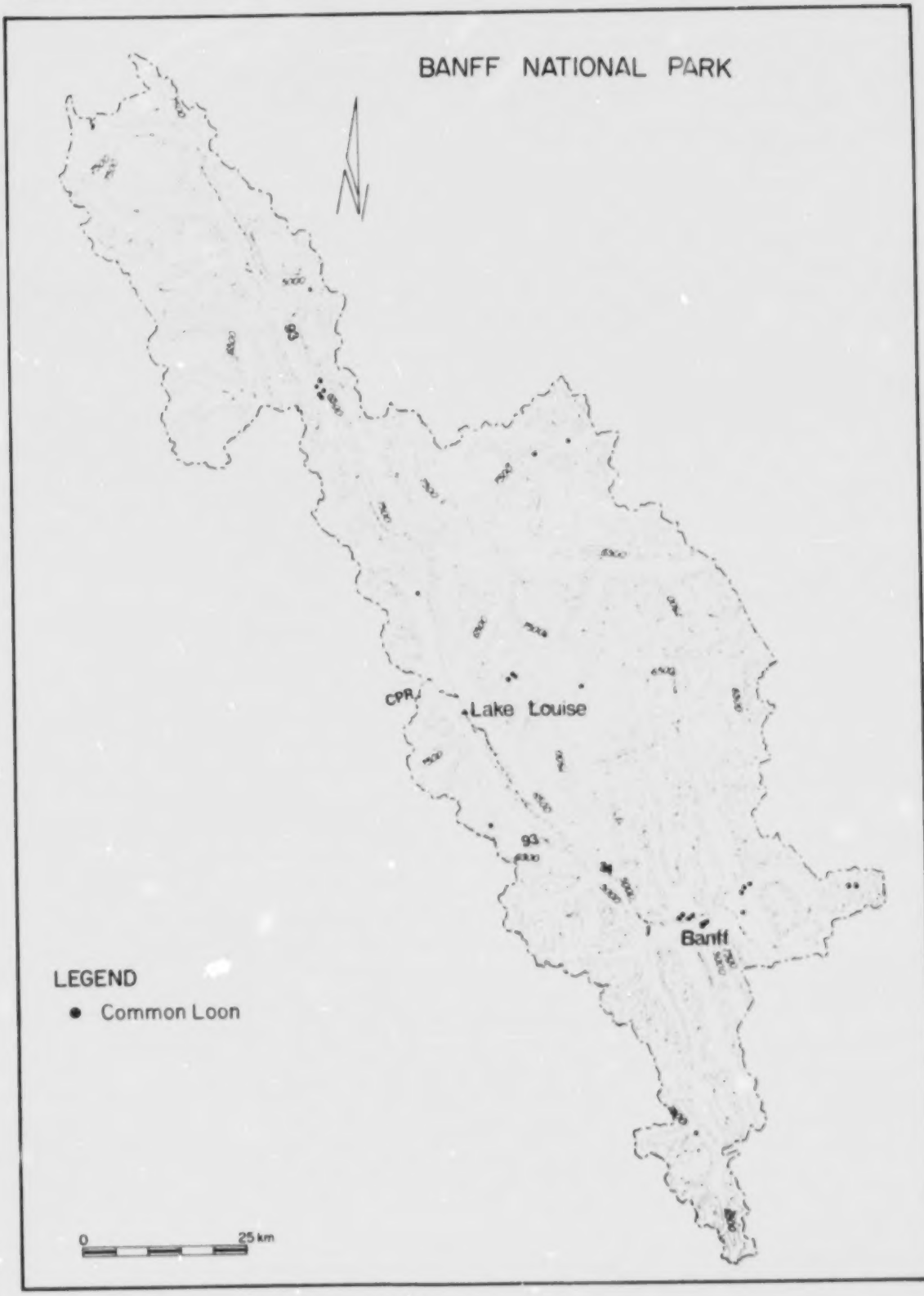
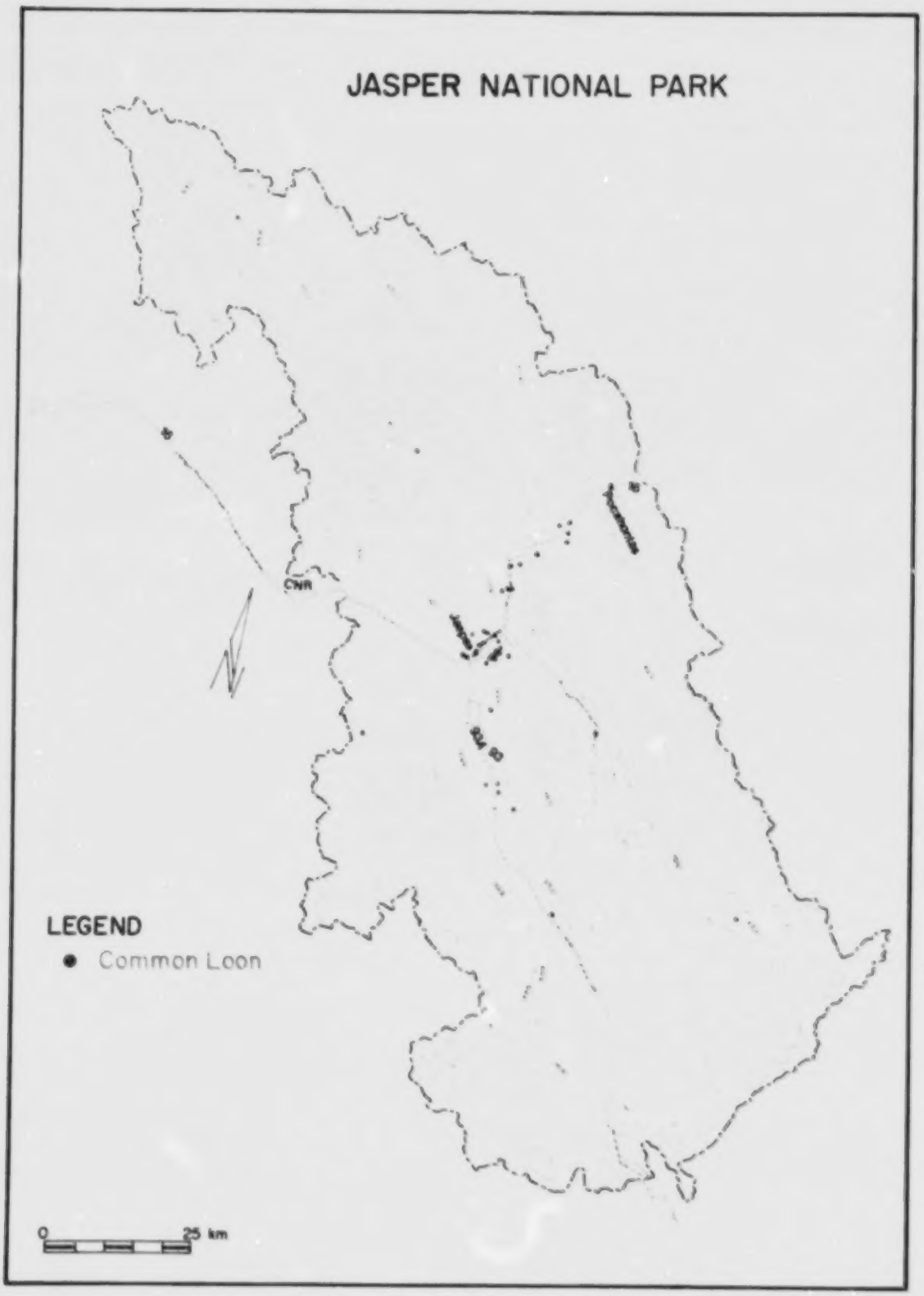


Figure 3.4. Distribution of Common Loon observations in Jasper.



ARCTIC LOON *Gavia arctica* **ARLO**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: very rare visitor
Winter: not recorded

The Arctic Loon is a circumpolar species which breeds throughout the western Canadian arctic (Godfrey 1966) and in extreme northeastern Alberta (Salt and Salt 1976). As this species migrates almost exclusively along ocean coasts, it is only rarely seen in Alberta and its appearances here are usually preceded by severe storms in British Columbia (M.T. Myres, U. of Calgary; pers. comm.).

There are only three records of this species in Banff and Jasper. A flock of about forty was seen on Pyramid Lake on 3 June 1980 (D.B.Donald); the flock had departed by the following day. One was seen on Lake Minnewanka on 28 October 1979. A specimen was collected at Maligne Lake on 27 July 1955 (Cowan 1955).

RED-THROATED LOON *Gavia stellata* **RELO**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare visitor
Winter: very rare visitor

The Red-throated Loon is a circumpolar species which breeds throughout most of arctic Canada and along parts of the Pacific Coast (Godfrey 1966).The species may breed in extreme northeastern Alberta (Salt and Salt 1976). As this species migrates almost exclusively along ocean coasts, it is only rarely seen in southern Alberta.

There are only two records of this species in Banff. An individual remained on Lake Minnewanka from 31 December 1974 to 2 January 1975 and is assumed to have died (Gordon 1975). Four were seen in Banff on 6 October 1966. Salt and Salt (1976) cite an old record from Banff but give no details. There are no Jasper records.

RED-NECKED GREBE *Podiceps grisegana* **(B)** **REGR**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: uncommon resident
Autumn: fairly common migrant
Winter: not recorded

The Red-necked Grebe breeds in western North America, northern Asia, and Europe (Godfrey 1966). It breeds throughout Alberta except in the southern prairies and is scarce in the Rocky Mountains (Salt and Salt 1976).

In Banff and Jasper the Red-necked Grebe is seen most regularly on Vermilion Lakes, Talbot Lake and Patricia Lake. There are very few breeding records.

Spring migration is during late April and May. Peak migration is in early May. Earliest record is 11 April 1979 at Talbot Lake. Maximum recorded count is 76 on 9 May 1977 at Vermilion Lakes.

Red-necked Grebes nest regularly at Vermilion Lakes, although usually fewer than two pairs are present. Earliest nest is 2 June 1977 at Vermilion Lakes. There is a slide of a Red-necked Grebe on a nest at Patricia Lake in the collection of the Jasper Interpretive Service; this is the only recorded nest in Jasper although up to 4 pairs of Red-necked Grebes are present during the breeding season at Patricia Lake and Talbot Lake.

Autumn migration lasts from late August until late October. Peak migration is in late August and early September. Maximum recorded count is 24 on 15 September 1978 at Talbot Lake. Latest record is 11 December 1968 at Snake Indian Lakes (Jasper warden card).

HABITAT

The Red-necked Grebe occurs in lakes and ponds of the montane and lower subalpine ecoregions. This species prefers shallow areas with extensive beds of emergent vegetation, particularly during the breeding season. During migration flocks of Red-necked Grebes may be seen in deeper water.

MANAGEMENT CONSIDERATIONS

The Red-necked Grebe is a species which is undergoing a continent-wide population decline and is under consideration as a threatened species in Canada. Protection of beds of emergent vegetation from disturbance by boaters and fishermen will ensure that Red-necked Grebes continue to have suitable breeding habitat in Banff and Jasper. Photography and other disturbance of nesting grebes should be discouraged.

HORNED GREBE *Podiceps auritus* **HOGR**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: rare visitor
Autumn: uncommon migrant
Winter: not recorded

The Horned Grebe breeds throughout most of the temperate regions of the Northern Hemisphere (Godfrey 1966). The species nests locally in all parts of Alberta except the Rocky Mountains (Salt and Salt 1976).

In Banff and Jasper the Horned Grebe is most regularly seen on Vermilion Lakes and Talbot Lake.

Spring migration is during April and May. Peak migration is in mid May. Earliest record is 11 April 1979 at Talbot Lake. Maximum recorded count is 58 on 9 May 1979 at Talbot Lake.

There are no nest records in Banff and Jasper although Horned Grebes have been recorded twice in the lower Athabasca River and North Saskatchewan River valleys in June.

Autumn migration lasts from mid September to early November. Peak migration is in September. Maximum recorded count is 12 on 24 September 1977 at Talbot Lake. Latest record is 8 November 1979 at Talbot Lake.

HABITAT

The Horned Grebe occurs only in ponds and backwaters of the montane and lower subalpine ecoregions. This species is usually found in shallow water with extensive beds of emergent vegetation, except during migration when it may be seen in deeper water.

EARED GREBE *Podiceps nigricollis* **EAGR**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: very rare visitor
Autumn: rare migrant
Winter: not recorded

The Eared Grebe breeds throughout much of western North America as well as parts of Eurasia and Africa (Godfrey 1966). In Alberta "the main breeding range of the Eared Grebe coincides roughly with the prairies and the parklands ... there are no nesting records for the Rocky Mountains" (Salt and Salt 1976).

In Banff and Jasper the Eared Grebe is usually seen among flocks of other grebes on such lakes as Vermilion Lakes and Talbot Lake.

Spring migration is during April and May. Earliest record is 29 April 1977 at Vermilion Lakes. Maximum recorded count is 8 on 18 May 1977 at Vermilion Lakes. There is one record during the breeding season: an Eared Grebe was seen on Edith Lake

on 8 June 1976 (Rob Kaye, pers. comm.).

There is no regular autumn migration. Maximum recorded count is four on 12 October 1975 at Vermilion Lakes.

HABITAT

The Eared Grebe occurs primarily on lakes in the montane and lower subalpine ecoregions. Although breeding Eared Grebes prefer shallow water with extensive beds of emergent vegetation, the species is most commonly seen in deeper water areas with other migrating waterfowl in Banff and Jasper.

WESTERN GREBE *Aechmophorus occidentalis* **WEGR**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: rare visitor
Autumn: fairly common migrant
Winter: not recorded

The Western Grebe breeds only in the Great Plains region of North America and in a few areas west of the Rocky Mountains (Godfrey 1966). In Alberta the species breeds throughout most of the prairies, parklands and southern boreal forest; however most lakes "... which formerly supported nesting colonies of Western Grebes are now popular vacation resorts, and ... nesting colonies are found today mainly on lakes unsuitable for human recreation... " (Salt and Salt 1976).

In Banff and Jasper the Western Grebe is seen regularly on Patricia and Pyramid Lakes, Talbot Lake, and Vermilion Lakes.

Spring migration is during late April and May. Peak migration is in May. Earliest record is 12 April 1979 at Talbot Lake. Maximum recorded count is 102 on 11 May 1979 at Talbot Lake. Latest record is 20 June 1965 at Vermilion Lakes.

Autumn migration lasts from August until early November. Peak migration is during mid and late September. Earliest record is 5 August 1977 at Vermilion Lakes. Maximum recorded count is 24 on 23 September 1977 at Vermilion Lakes. Latest record is 8 November 1978 on Talbot Lake.

HABITAT

The Western Grebe occurs primarily on large ponds and lakes in the montane and lower subalpine ecoregions. It is usually found on lakes of moderate depth where they may be in proximity to beds of emergent vegetation or in open water.

PIED-BILLED GREBE *Podilymbus podiceps* **PBGR**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

The Pied-Billed Grebe occurs throughout most of the temperate and tropical regions of North and South America (Godfrey 1966). The species breeds throughout Alberta but is "... mainly a transient in the Rocky Mountains... " (Salt and Salt 1976).

In Banff and Jasper the Pied-Billed Grebe is heard and occasionally seen on the Vermilion Lakes, Cave and Basin Swamp, Talbot Lake, Pocahontas Ponds and floodplain ponds of the lower Athabasca River.

Spring migration is during May. Earliest record is 29 April 1978 at Vermilion Lakes. Maximum recorded count is 3 on 20 May 1977 at Vermilion Lakes.

There are two breeding records: a nest with seven eggs on 14 June 1968 (Gordon 1975) and an adult with five young in 24 July 1978 both at Vermilion Lakes but Pied-Billed Grebes are present in the lower Athabasca River valley during the breeding season and no doubt breed there.

Autumn migration lasts from late August until early November. Maximum recorded count is 8 on 5 September 1977. Latest record is 8 November 1978 on Talbot Lake.

HABITAT

The Pied-Billed Grebe occurs in ponds, backwaters and lake edges in the montane ecoregion. Beds of sedge, rushes or horsetail, and flooded willow thickets, are the preferred habitat of this species. Pied-Billed Grebes are rarely seen in the open except during early morning and even then they remain close to cover. During autumn migration this species is more likely to be seen in open water.

WHITE PELICAN *Pelecanus erythrorhynchos* **WHPE**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: not recorded
Autumn: very rare visitor
Winter: not recorded

The White Pelican breeds in parts of the Great Plains and northern Prairie Provinces, as well as locally west of the Rocky Mountains (Godfrey 1966). In Alberta the White Pelican is now confined to a few isolated colonies mostly in boreal regions (Salt and Salt 1976).

In Banff and Jasper the White Pelican is very rare, only having been recorded three times. An individual remained on 2nd Vermilion Lake during 17 and 18 May 1974 (Gordon 1975). Eleven were observed on Talbot Lake on 9 September 1968 (A. Loewen, Jasper Warden files). A specimen was collected in Banff by Chief Warden Sibbald on 14 October 1914 (Clarke and Cowan 1945).

HABITAT

The White Pelican usually frequents "... In breeding season, interior lakes in both treeless and forested country. In winter the sea-coast and freshwater lakes" (Salt and Salt 1976). All Banff and Jasper records are from large shallow lakes in the montane ecoregion.

DOUBLE-CRESTED CORMORANT *Phalacrocorax auritus* **DOCO**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare visitor
Winter: not recorded

The Double-crested Cormorant breeds in southwestern Alaska and in temperate and tropical areas of North America east of the Rocky Mountains (Godfrey 1966). Most Alberta breeding colonies are in the boreal forest region although some lakes in the parklands and prairies have or formerly had colonies (Salt and Salt 1976).

In Banff and Jasper the Double-crested Cormorant is very rare; there is only a single record. An individual was observed on 22 October 1979 on Leach Lake (MAS, D.B.Donald).

HABITAT

Double-crested Cormorants usually frequent "... Freshwater lakes and rivers... " (Godfrey 1966). The Jasper record was in a small lower subalpine lake.

GREAT BLUE HERON *Ardea herodias* **GRHE**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: very rare visitor
Autumn: uncommon migrant
Winter: very rare visitor

The Great Blue Heron breeds throughout most of the temperate and tropical regions of North America although it is local west of the Rocky Mountains (Godfrey 1966). In Alberta the species occurs mostly south of Lesser Slave Lake and east of the Rockies, but within this large area "... the number and size of the breeding colonies have diminished... " over the last century (Salt and Salt 1976).

In Banff and Jasper the Great Blue Heron occurs primarily in the lower Bow River and lower Athabasca River valleys, and there are single records from the lower Brazeau River, lower North Saskatchewan River, and Siffleur River valleys. It is observed regularly in late summer at Pocahontas Ponds.

Spring migration is during May. Earliest record is 11 April 1969 at Talbot Lake (Loewen 1970). Maximum recorded count and latest record is 2 on 9 May 1979 on the

lower Athabasca River.

Autumn migration is during August and September. Peak migration is in August. Earliest record is 1 August 1978 on the lower North Saskatchewan River. Maximum recorded count is 8 on 8 and 23 August 1978 at Pocahontas Ponds. Latest record is 29 September 1978 at Pocahontas Ponds.

There are two records of a Great Blue Heron remaining in Banff during the winter. An individual remained on the lower Bow River until mid-winter in 1969 but apparently did not survive (Gordon 1975) and a heron was resident at Vermilion Lakes in February 1983 (GLH).

HABITAT

The Great Blue Heron occurs primarily along rivers and lakes in the montane and lower subalpine ecoregions. River edges and bars, muddy edges of lakes and ponds, wetlands, and alluvial meadows are favoured feeding habitats of this species. Potential nesting habitat in the form of mature balsam poplar and mixed forest exists along the lower Athabasca River, lower Bow River and Miette River.

GREEN HERON *Butorides virescens* **GNHE**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The green heron is a North American species which breeds from western Washington and Nevada, and southern Ontario and New Brunswick, south to Central America and Columbia (Godfrey 1966). There have been no documented (ie. photographed or collected) cases of the species occurring in Banff or Jasper.

There is only one record of a green heron in Banff: one was seen at Vista Lake by Scott O'Keefe on 5 June 1978, following three days of stormy weather (Banff administrative files).

HABITAT

Green herons usually frequent "... sluggish streams, ponds and marshes sheltered by bushes and trees; alder thickets on drowned land" (Godfrey 1966). The Banff record was on the forested border of an upper subalpine lake.

GREAT EGRET *Casmerodius albus* **GREG**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Great Egret breeds throughout most of the Western Hemisphere, south of Canada (Godfrey 1966). In Alberta there are only four records (Salt and Salt 1976). There is a single record of a Great Egret from Banff. An individual was observed by a group of birdwatchers in the Cave and Basin Swamp on 31 May 1967 (Gordon 1975).

HABITAT

Great Egrets usually occur in "... Marshes, irrigated lands, ponds, shores, mudflats... " (Peterson 1969). The Banff record was in a marshy meadow adjacent to a willow swamp, in the montane ecoregion.

AMERICAN BITTERN *Botaurus lentiginosus* **(B)** **AMBI**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: rare resident
Autumn: not recorded
Winter: not recorded

The American Bittern breeds throughout most of the temperate region of North America (Godfrey 1966). In Alberta this species occurs wherever suitable habitat is available (Salt and Salt 1976).

In Banff and Jasper the American Bittern occurs regularly only at Vermilion Lakes. There are single records from the middle Bow River, Mistaya River, lower North Saskatchewan River, upper North Saskatchewan River and lower Brazeau River valleys.

Spring migration is during May. Earliest record is 5 May 1977 at Vermilion Lakes. Maximum recorded count is 3 on 28 May 1978 at Vermilion Lakes.

There is only one recorded nest of this species in Banff, and none in Jasper. A nest was found on 27 June 1911 at Vermilion Lakes (Clarke and Cowan 1945).

American Bitterns have not been recorded in Banff and Jasper in the autumn, nor do they remain during winter. They remain in the prairie regions of Alberta until late October and early November (Salt and Salt 1976).

HABITAT

The American Bittern occurs along lakes and backwaters and in wetlands in the montane and, less frequently, lower subalpine ecoregions. Suitable habitat in the form of lake and pond edges and marshes where there are extensive stands of cattails, tall sedges and grasses and flooded willows are of very limited extent in Banff and Jasper.

WHISTLING SWAN *Olor columbianus* **WHSN**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: very rare visitor
Autumn: rare migrant
Winter: very rare visitor

The Whistling Swan breeds in Alaska and the low Arctic of northern Canada (Godfrey 1966). In Alberta the species is an abundant migrant (Salt and Salt 1976).

In Banff and Jasper the Whistling Swan is seen most frequently at Talbot Lake and Vermilion Lakes, but its occurrence is irregular.

Spring migration is in late April and early May. Earliest record is 12 April 1977 at Talbot Lake. Maximum recorded count is 26 on 24 April 1959 and 26 April 1971 on Talbot Lake (Jasper warden cards). Latest record is 22 May 1969 at Willow Creek (Carbyn 1972a).

Whistling Swans do not breed in Banff and Jasper. An individual remained on Isabella Lake near the head of the Siffleur River during June and July of 1978 but fell victim to an unknown predator in late August.

Autumn migration is during October and November. Earliest record is 9 October 1968 at Talbot Lake (Loewen 1970). Maximum recorded count is 22 on 9 October 1968. Latest record is 9 November 1974 (Jasper warden cards).

Whistling Swans do not winter in Banff and Jasper, however an individual was observed near Bow Falls on 19 December 1976 (GLH).

HABITAT

Whistling Swans occur primarily on large ponds and lakes in the montane and lower subalpine ecoregions. Although migrant flocks may be seen resting on deep water, they are more commonly seen in water shallow enough to allow bottom-feeding, frequently near beds of sedge and rushes.

TRUMPETER SWAN *Olor buccinator* **TRSN**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Trumpeter Swan breeds locally in northwestern North America (Godfrey 1966). In Alberta the species breeds in the Peace River area and the Cypress Hills and has recently become established in other parts of southern Alberta (Salt and Salt 1976).

In Banff and Jasper the Trumpeter Swan may formerly have bred, but there are only three records from the last forty years, all during the spring migration period. One was seen on 8 June 1943 at Vermilion Lakes (Clarke and Cowan 1945). One was seen at

Pocahontas Ponds on 3 May 1945 (Cowan 1955). One was reported at Maligne Lake on 22 May 1958 (Jasper warden cards). The numerous records from 1953 to 1958 in Jasper warden files are assumed to be Whistling Swans since no whistlers were recorded during these years.

Trumpeter Swans do not remain in Banff and Jasper during the breeding season, although "... a pair of swans present on Fortress Lake in June 1930, and again in June 1931, was probably of this species" (Cowan 1955).

HABITAT

Trumpeter Swans usually frequent "... Lakes, large sloughs, rivers; sometimes feeds in fields... " (Godfrey 1966) and "... nest on rather small ponds and sloughs, often using a muskrat house or beaver lodge... " (Salt and Salt 1976).

The most extensive areas of potential breeding habitat for this species in Banff and Jasper are Talbot Lake, Vermilion Lakes, Snake Indian Lakes, and the backwaters of the lower Athabasca River, Bow River, lower Brazeau River and Miette River where numerous small ponds and oxbows are intermingled with sedge meadows and open coniferous bogs.

CANADA GOOSE *Branta canadensis* **(B)** **CAGO**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: common resident
Autumn: common migrant
Winter: not recorded

The Canada Goose breeds in most of Canada and parts of the northwestern United States. It occurs throughout Alberta.

In Banff and Jasper the Canada Goose occurs regularly in ponds and backwaters along the lower Athabasca River, Bow River, lower Brazeau River and Miette River and the Snake Indian Lakes (Figure 3.5, 3.6). Talbot Lake supports at least 5 nesting pairs of Canada Geese. Cowan (1955) located 16 nests at Talbot Lake in May 1946 and estimated the park nesting population at between 50 and 100 pairs. The present Jasper population is probably between 25 and 50 pairs. Clarke and Cowan (1945) refer to only 2 nests in Banff and state that "... Nestings are evidently not as common now as formerly". There are only 2 nest records on file since 1975 in Banff. However Canada geese nest regularly at Vermilion Lakes and the Healy backswamp and are probably somewhat more common now than in the forties.

Spring migration is during April and May, peaking in mid and late April. Earliest record is 13 March 1977 on the lower Bow River. Maximum recorded count is 180 on 10 April 1963 along the lower Athabasca River (Jasper warden cards).

Earliest recorded nest is 16 April 1978 in an osprey nest on Second Vermilion Lake. Earliest recorded brood is 18 May 1977 at Talbot Lake.

Autumn migration lasts from August until late October. Maximum recorded count and latest record is 125 on 29 October 1973 at Jasper National Park Lodge golf course (Jasper warden cards).

Figure 3.5. Distribution of Canada Goose observations in Banff.

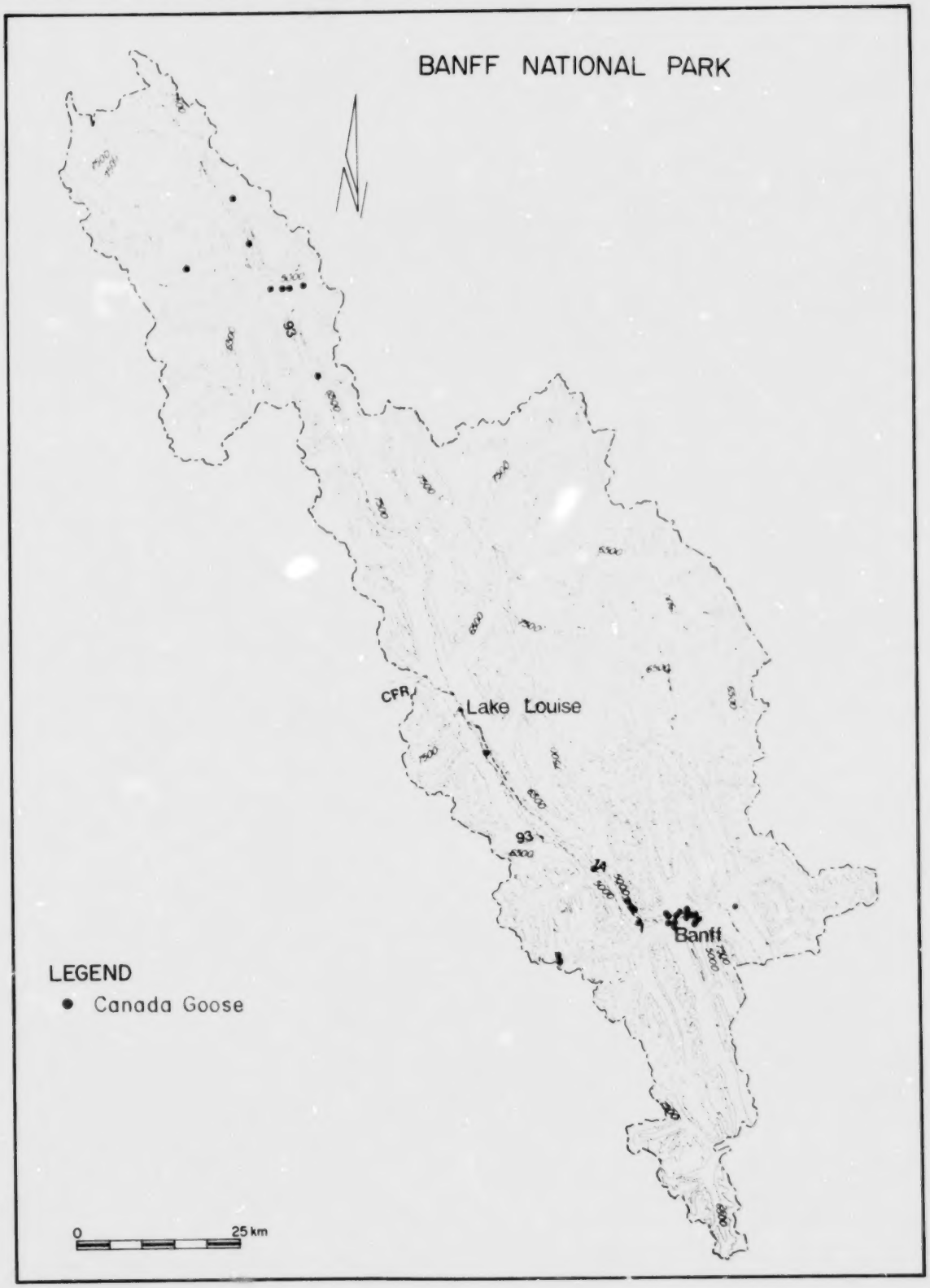
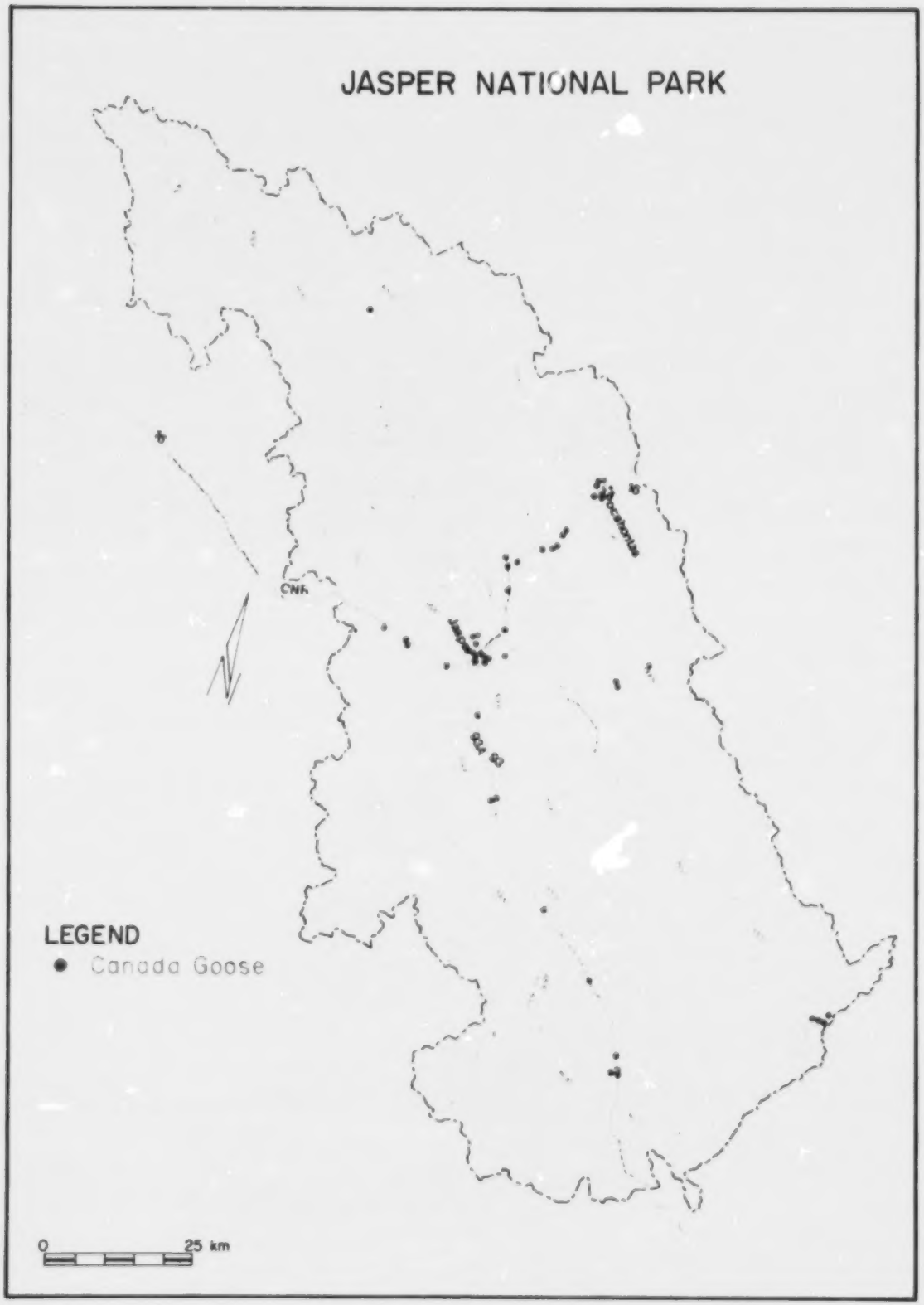


Figure 3.6. Distribution of Canada Goose observations in Jasper.



Canada geese do not winter in Banff and Jasper, although a few occasionally remain near Calgary (Salt and Salt 1976).

HABITAT

The Canada Goose occurs primarily along rivers and on lakes and ponds in the montane and lower subalpine ecoregions. Grass and sedge meadows are used by Canada geese for foraging; geese are regularly seen grazing the Jasper National Park Lodge golf course and the highway verge along Talbot Lake. Osprey nests, small islands and grassy tussocks along lake and pond edges, beaver and muskrat houses, and islands in rivers are used for nesting. All of the 16 nests observed at Talbot Lake in May 1946 (Cowan 1955) were on islands, as were all the nests recorded during the inventory, except 2 in osprey nests.

BRANT *Branta bernicla* **BRAN**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare visitor
Winter: not recorded

The Brant breeds in the arctic regions of the Northern Hemisphere, including the western arctic of North America (Godfrey 1966). It migrates and winters along the ocean coast and is very rarely seen in Alberta on migration (Salt and Salt 1976). There is a single record of this species in Jasper. A brant was photographed at Lake Annette on 18 October 1959 by Mr. Fred Martel of Jasper (Salt 1961). This is an exceptional record of a maritime species and not likely to be repeated.

SNOW GOOSE *Chen caerulescens* **SNGO**

STATUS AND DISTRIBUTION

Spring: rare visitor
Summer: very rare visitor
Autumn: rare visitor
Winter: not recorded

The Snow Goose breeds from northeastern Siberia east across the high and mid-Arctic to northern Greenland (Godfrey 1966). In Alberta snow geese are regular spring and autumn migrants (Salt and Salt 1976).

In Banff and Jasper the Snow Goose has been recorded fewer than 10 times. Most records are of one or two individuals in company of flocks of Canada geese but there is one record of a flock of 200 that remained in Jasper during 9 and 10 May 1944 (Cowan 1955).

Spring migration is during May. Earliest record is 26 April 1977 at Vermilion Lakes. Latest record is 23 May 1975 along the lower Athabasca River (Jasper warden cards).

There is only one record of a Snow Goose during the breeding season; one was seen with several Canada geese on Vermilion Lakes on 13 June 1943 (Clarke and Cowan 1945).

There are two late autumn records: 50 on the Southesk River on 14 November 1957 (M.Elder) and 10 on 15 October 1971 in the Miette valley (J.Turnbull). The two records of Ross' Goose in Jasper lack details and are more likely to be this species.

HABITAT

Migrating snow geese have been seen only on lakes, large ponds, and rivers in the montane and lower subalpine ecoregions.

MALLARD *Anas platyrhynchos* **(B)** **MALL**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: common resident
Autumn: common migrant
Winter: uncommon resident

The Mallard breeds throughout North America, Europe, and Asia (Godfrey 1966). It occurs throughout Alberta and remains in the province all winter wherever extensive areas of water remain open (Salt and Salt 1976).

In Banff and Jasper the Mallard occurs in every major drainage, but the majority of the parks' mallards are in backwaters and ponds of the lower Athabasca River, lower Bow River, and Miette River (Table 3.7, 3.8).

Spring migration is during April and May. Peak migration is in mid April. Earliest record is 17 March 1979 at the Cave and Basin ponds. Maximum recorded count is 315 on 10 April 1978 in the lower Bow River valley.

Mallards nest in suitable habitat throughout Banff and Jasper. Earliest recorded nest is 21 May 1979 in the lower Athabasca River valley. Earliest recorded brood is 3 June 1976 at the Mile 18 Pond in Jasper.

Autumn migration lasts from late August until freeze-up in November. Peak migration is during the last half of September. Maximum recorded count is 302 on 21 September 1978 along the lower Athabasca River valley.

Small numbers of Mallards remain in Banff and Jasper during the winter, most regularly in the vicinity of Banff townsite and along the lower Athabasca River. Two hundred Mallards were counted on the 16 December 1979 Banff Christmas Bird Count.

HABITAT

The Mallard occurs primarily in lakes, ponds, wetlands and backwaters of the montane and lower subalpine ecoregions, but may be found in ponds in the upper subalpine ecoregion also. Mallards nest in a variety of upland habitats, often far from water, but feed and raise their young in shallow ponds and lake margins having abundant cover in the form of sedge beds or submerged willows. Migrating Mallards occupy shallow water areas in lakes, ponds and rivers.

Figure 3.7. Distribution of Mallard observations in Banff.

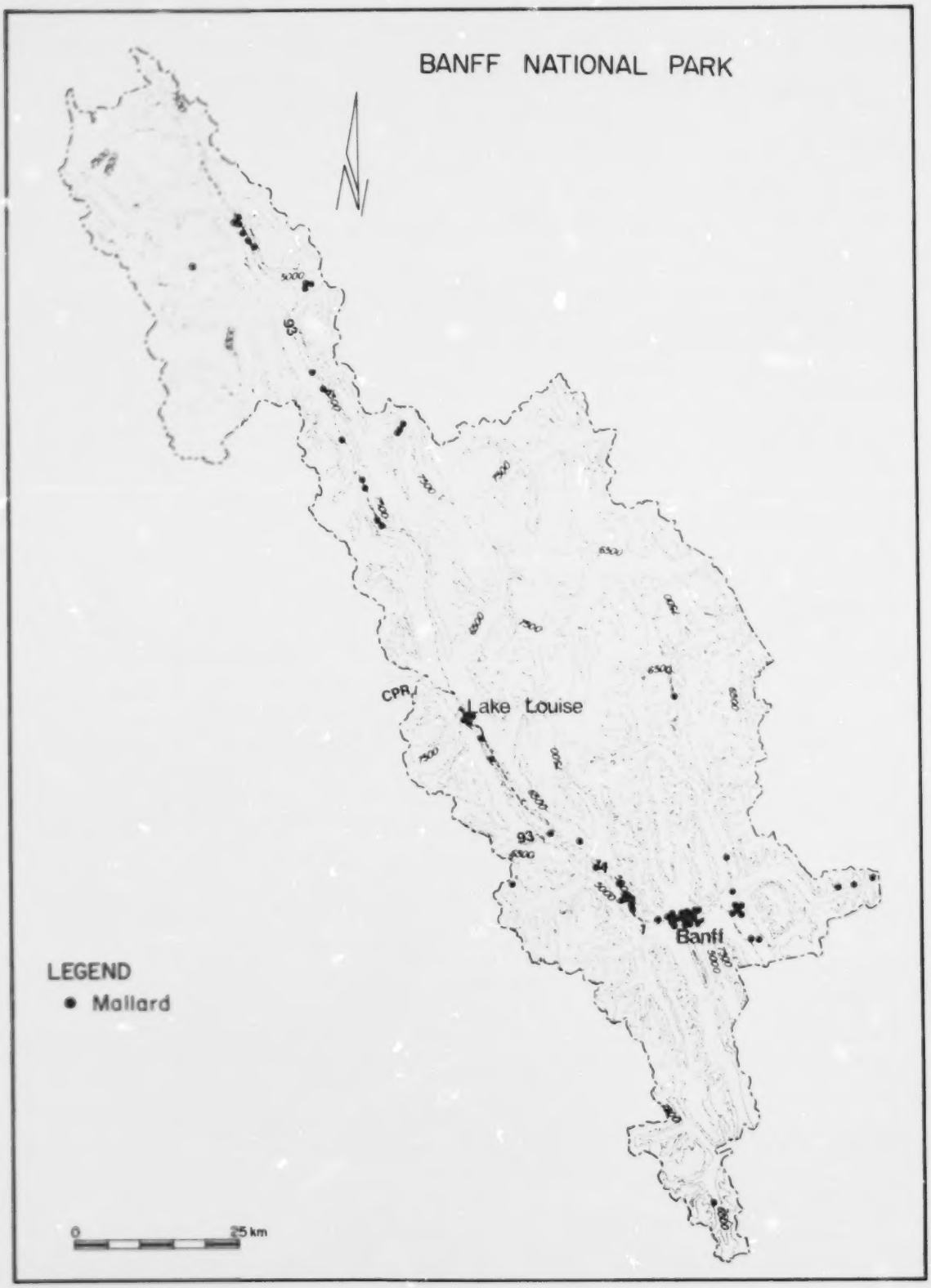
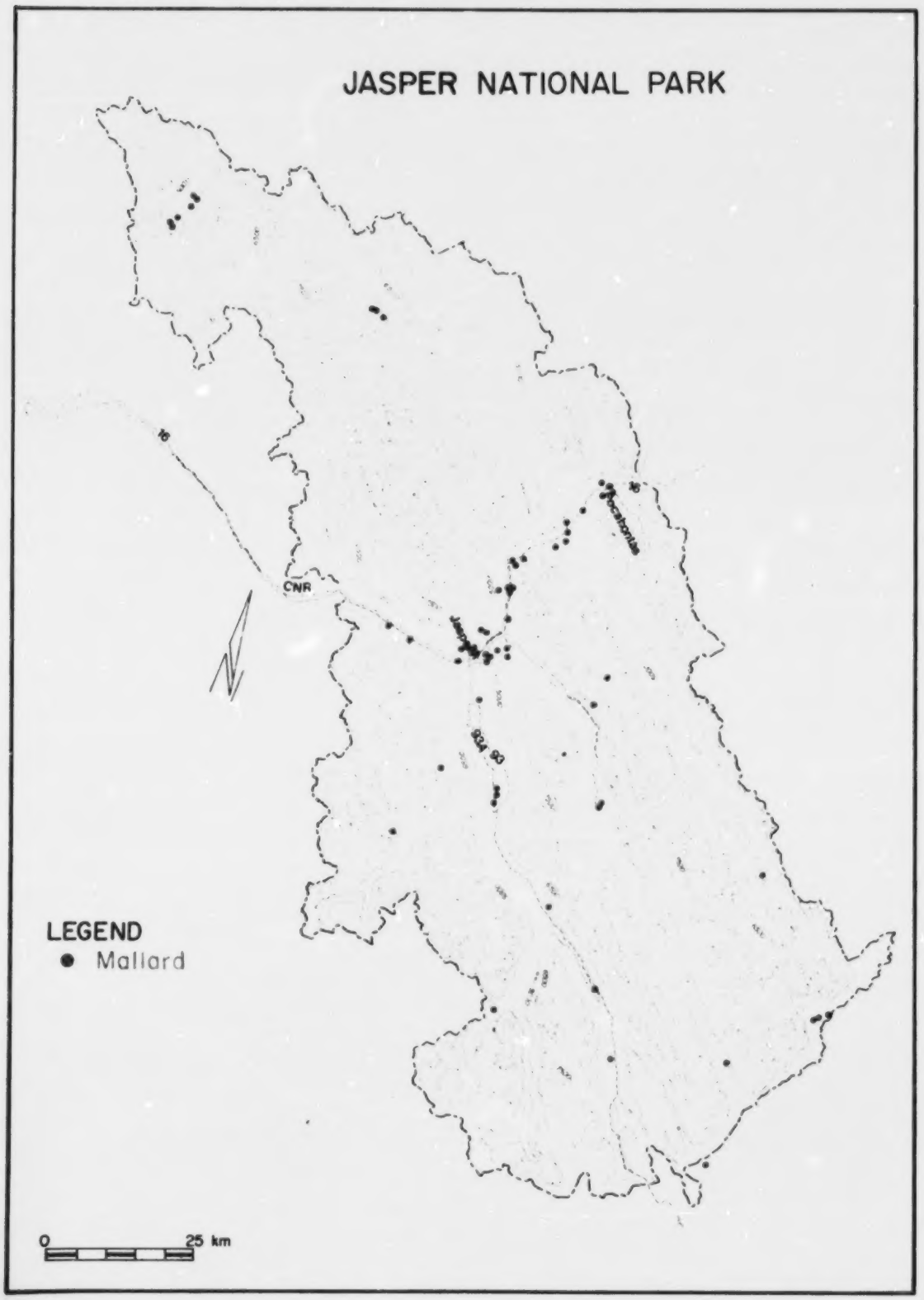


Figure 3.8. Distribution of Mallard observations in Jasper.



GADWALL *Anas strepera* **GADW**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: rare visitor
Autumn: rare migrant
Winter: not recorded

The Gadwall breeds in temperate regions of western North America, Europe and Asia (Godfrey 1966). In Alberta Gadwalls breed throughout the southern two-thirds of the province and locally in the northern part (Salt and Salt 1976).

In Banff and Jasper the Gadwall is an uncommon migrant in the lower Athabasca River and lower Bow River valleys and is less regularly seen elsewhere.

Spring migration is during May and June. The earliest record is 29 April 1977 at Vermilion Lakes. Maximum recorded count is three on 9 May 1977, also at Vermilion Lakes.

There are only two records of Gadwalls during the breeding season: two were seen on 9 and 10 June 1979 at the Jasper sewage lagoon (DJH). There is no evidence that they breed in Banff and Jasper.

There are only two records of Gadwalls during autumn migration; 24 September 1977 on Mile 18 Pond, and 12 October 1975 at Vermilion Lakes (Bow Valley Naturalists 1978).

HABITAT

The Gadwall occurs primarily in wetlands, ponds, and shallow parts of lakes in the montane ecoregion.

This species "... prefers sloughs and shallow margins of lakes bordered by good cover... " (Godfrey 1966) in the form of sedge and grass meadows and dense willows.

PINTAIL *Anas acuta* **PINT**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: very rare visitor
Autumn: fairly common migrant
Winter: very rare visitor

The Pintail breeds throughout most of the Northern Hemisphere except in the high Arctic (Godfrey 1966). This species is one of the most common and ubiquitous ducks of Alberta, occurring throughout the province (Salt and Salt 1976).

In Banff and Jasper, most records of this species are from Mile 18 Pond, Pocahontas Ponds, and the Vermilion Lakes area.

Spring migration is during April and May. Peak migration is the last half of April. Earliest record is 2 April 1978 at Vermilion Lakes. Maximum recorded count is 400 at

Talbot Lake on 22 April 1973 (Jasper warden cards).

There are very few records of Pintails during the breeding season and no records of nesting.

Autumn migration lasts from mid August until freeze-up in early November. Peak migration is mid September. Maximum recorded count is 182 on 1 September 1977 in the lower Athabasca River valley. Latest record is 19 November 1968 at Pocahontas Ponds (Loewen 1970).

There are only two winter records of Pintail; one was seen at Bow Falls on 25 February 1941 (Clarke and Cowan 1945) and one was seen on the 1979 Banff Christmas Bird Count (16 December).

HABITAT

The Pintail occurs primarily in wetlands and shallow parts of ponds and lakes in the montane and lower subalpine ecoregions. Pintails feed in shallow water, particularly where there are extensive stands of emergent sedge and rush vegetation.

GREEN-WINGED TEAL *Anas crecca* **(B)** **GRTE**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: uncommon resident
Autumn: common migrant
Winter: not recorded

The Green-winged Teal breeds from northern Canada to the southern U.S.A. (Godfrey 1966). The species occurs throughout Alberta (Salt and Salt 1976).

In Banff and Jasper most observations are from the Athabasca River, Bow River, Brazeau River, Red Deer River, and Snake Indian River valleys, but Green-winged Teal occur throughout the parks (Figure 3.9, 3.10).

Spring migration is during April and May. Peak migration is late April and early May. Earliest record is 30 March 1969 on Jasper Lake (Loewen 1970). Maximum recorded count is 7 on 9 May 1977 in the lower Bow River valley.

There are breeding records from both Banff and Jasper. Earliest record of young is 28 June 1978 on Simon Creek.

Autumn migration lasts from August until late October. Peak migration is mid and late August. Maximum recorded count is 300 on 25 August 1979 in the lower Athabasca River valley. Latest record is 13 October 1980 at Wigmore Lake.

HABITAT

The Green-winged Teal occurs in wetlands, ponds, lake margins, beaverponds and slow-moving streams in the montane, lower subalpine, and upper subalpine ecoregions. It prefers small, shallow water bodies or complex shorelines, with extensive cover in the form of sedge beds and seasonally-flooded willow stands. On migration it may be found in more open water and larger lakes than during the breeding season.

Figure 3.9. Distribution of Green-winged Teal observations in Banff.

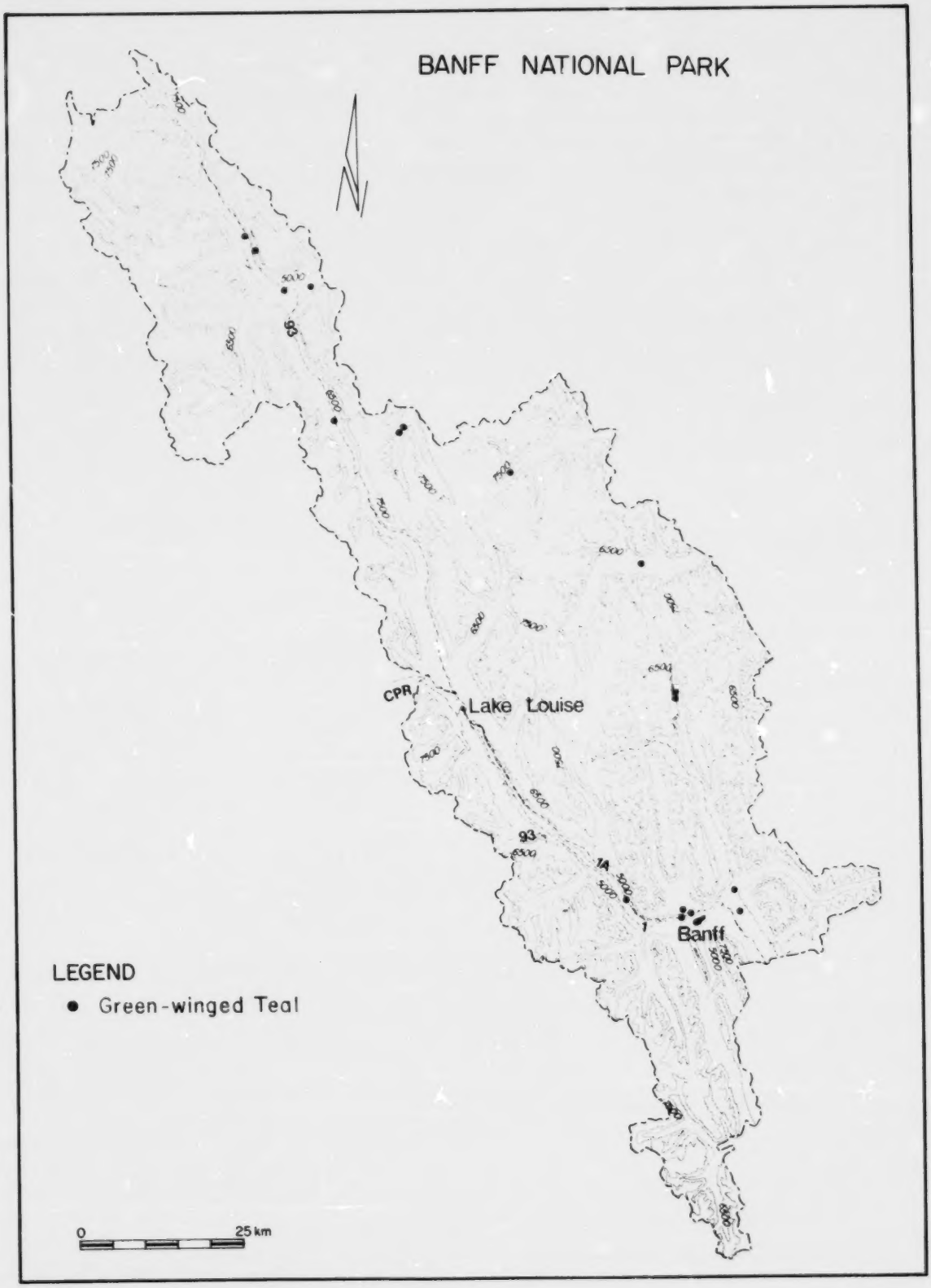
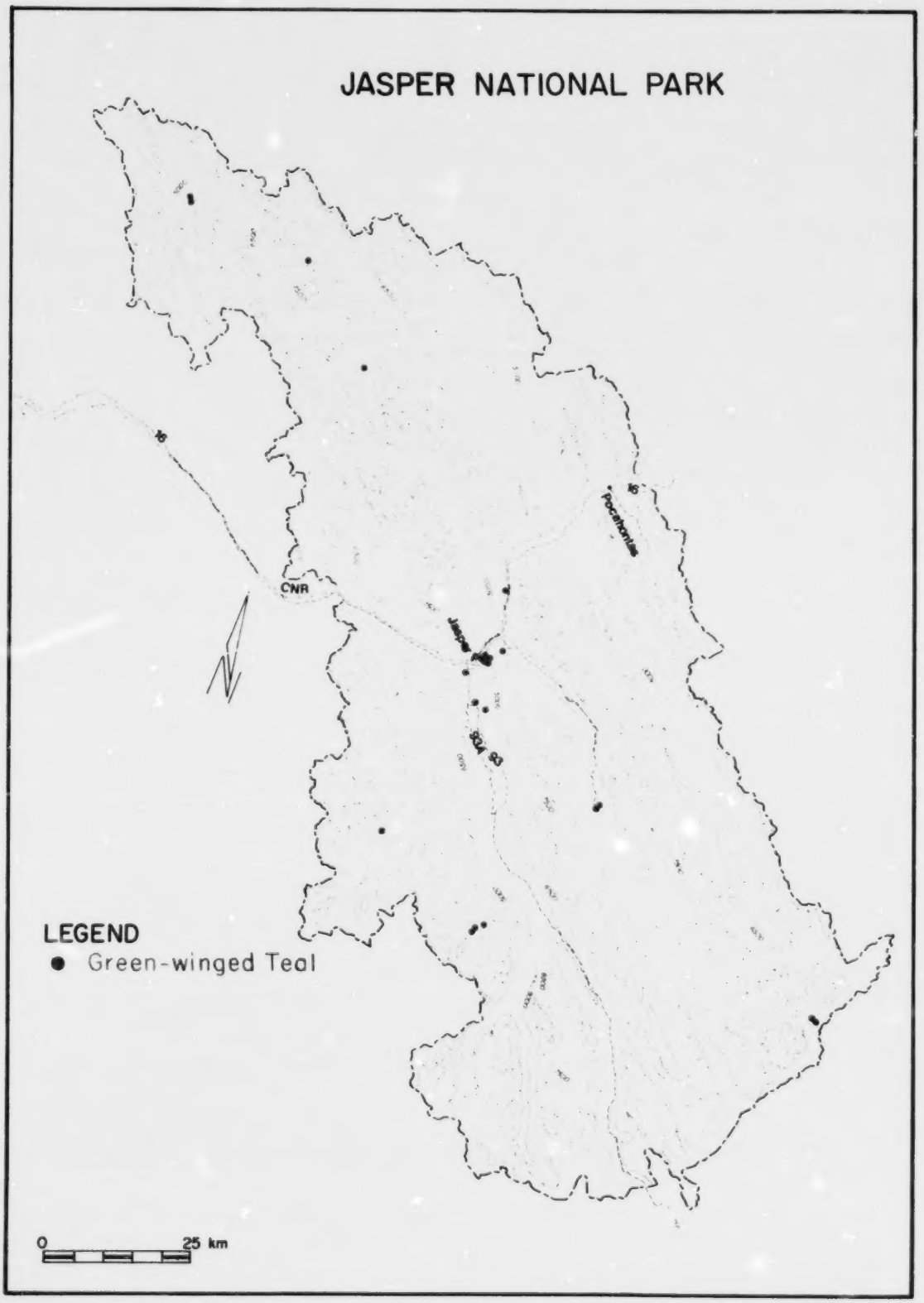


Figure 3.10. Distribution of Green-winged Teal observations in Jasper.



BLUE-WINGED TEAL *Anas discors* **(B)** **BLTE**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: very rare visitor

The Blue-Winged Teal breeds throughout most of temperate North America (Godfrey 1966). It occurs throughout Alberta (Salt and Salt 1976). In Banff and Jasper it is regularly observed only in the lower Athabasca River and lower Bow River valleys.

Spring migration is during late April and May. Peak migration is early May. Earliest record is 24 April 1977 at Vermilion Lakes. Maximum recorded count is 55 on 14 May 1977 at Mildred Lake.

There is one nest record on 16 June 1979 in the Clearwater River valley. Earliest recorded young are 4 August 1976 on Talbot Lake.

Autumn migration lasts from mid-August until October. Peak migration is September. Maximum recorded count is 48 on 1 September 1977 in the lower Athabasca River valley. Latest record is 7 October 1978 in the lower Cascade River valley.

This species does not usually winter in Banff and Jasper. There are only two records; three were seen on the 16 December 1979 Banff Christmas Bird Count, and one was reported at Rocky Forks on 7 February 1980 (JLK).

HABITAT

The Blue-Winged Teal occurs in wetlands and shallow ponds and lake edges in the montane and lower subalpine ecoregions. Abundant cover in the form of sedge beds and seasonally flooded willow stands are important to teal during the breeding season. During migration this species may be found in more open water, but it still prefers the shallows.

CINNAMON TEAL *Anas cyanoptera* **(b?)** **CITE**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon visitor
Autumn: very rare migrant
Winter: not recorded

The Cinnamon Teal breeds locally along the western half of North and South America (Godfrey 1966). In Alberta it apparently only became established as a nesting species in the 1950's; it now occurs uncommonly as far north as Tofield (Salt and Salt 1976).

In Banff and Jasper this species is uncommon, being seen most regularly in the lower Athabasca River valley and at Vermilion Lakes.

Spring migration is during late April and May. Earliest record is 23 April 1977 at Pocahontas Ponds. Maximum recorded count is ten on 12 May 1977 at Vermilion Lakes

(Bow Valley Naturalists 1978).

There are no nesting records; however, pairs have been seen in June on Pocahontas Ponds and Vermilion Lakes.

There is only one autumn record; an individual was observed on 9 September 1976 at the Cave and Basin Pond (McIvor and McIvor 1980).

HABITAT

The Cinnamon Teal occurs in marshy areas in the montane ecoregion. This species is usually found where abundant cover in the form of extensive sedge beds and seasonally flooded willows is available.

EUROPEAN WIGEON *Anas penelope* **EUWI**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: not recorded
Autumn: not recorded
Winter: not recorded

The European wigeon breeds in Iceland and northern Eurasia (Godfrey 1966). Only one individual has ever been collected in Alberta, and two other sightings are on record (Salt and Salt 1976).

In Jasper there is only one record: a male was observed on 3 May 1945 at the eastern end of Talbot Lake (Cowan 1955).

AMERICAN WIGEON *Anas americana* **b?** **AMWI**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: very rare visitor
Autumn: fairly common migrant
Winter: not recorded

The American Wigeon breeds in Canada mostly west of Ontario, and locally in the western United States (Godfrey 1966). The species breeds throughout Alberta except in the mountains (Salt and Salt 1976).

In Banff and Jasper the American Wigeon occurs regularly on Vermilion Lakes, Jasper Lake, Pocahontas Pond, Mile 18 Pond, and the Cave and Basin Pond.

Spring migration is during April and May. Peak migration is in mid April. Earliest record is 2 April in the lower Bow River valley. Maximum recorded count is 100 on 10 April 1978, in the lower Bow River valley. Latest spring record is 7 June 1980 at Snake Indian Lakes.

There are three summer records of American Wigeon: an unknown number on 21 June 1967, one on 9 July 1977 in the upper Bow Valley (MED), and a female with eight young on 2 August 1945 at First Vermilion Lake.

Autumn migration is during August and September, with only a few birds remaining through October. Peak migration is late August and early September. Earliest autumn record is 9 August 1979 at the Jasper sewage lagoon. Maximum recorded count is 43 on 17 September 1977 in the lower Athabasca River valley. Latest record is 29 October 1978 in the lower Athabasca River valley.

HABITAT

The American Wigeon occurs in lakes, ponds and wetlands and on river bars in the montane and lower subalpine ecoregions. Mudflats and sedge beds are favoured by this species.

NORTHERN SHOVELER *Anas clypeata* **SHOV**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon visitor
Autumn: uncommon migrant
Winter: not recorded

The Northern Shoveler breeds in western North America and parts of Europe and Asia (Godfrey 1966). It occurs throughout Alberta but is scarce in the mountains (Salt and Salt 1976).

In Banff and Jasper the Northern Shoveler occurs primarily in the lower Athabasca River and lower Bow River valleys.

Spring migration is during April and May. Earliest record is 15 April 1977 in the lower Bow River valley. Maximum recorded count is 61 on 11 May 1976 in the lower Athabasca River valley.

Northern Shovelers rarely remain in Banff and Jasper during the breeding season and there is no evidence to suggest that they breed. There is a record of a pair at the Jasper sewage lagoon on 9 June 1979 (DJH) and a male at Eisenhower junction on 24 June 1980 (GLH).

Autumn migration is during August and September. Earliest record is 22 August 1978 at Waterfowl lakes. Maximum recorded count is 70 on 25 August 1976 at the Jasper sewage lagoon. Latest record is 18 November 1979 on the Bow River.

HABITAT

The Northern Shoveler occurs in lakes and ponds in the montane and lower subalpine ecoregions. This species frequents shallow water with muddy bottoms, frequently in or near emergent sedge beds.

WOOD DUCK *Aix sponsa* **(B)** **WODU**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: very rare resident
Autumn: not recorded
Winter: not recorded

The Wood Duck is a North American species that breeds from parts of southern Canada south to Cuba and the Gulf Coast (Godfrey 1966). The species is rare in Alberta and is known to have bred in only two localities (Salt and Salt 1976).

In Banff the Wood Duck has been recorded 11 times since 1975 in the lower Bow River valley and at Johnson Lake. The largest count was a male and 3 females on 21 April 1976 near the Brewster riding corrals (McIvor and McIvor 1980). Most sightings have been at Vermilion Lakes, Fortymile Creek, the corrals, and Johnson Lake.

All but one Banff record were during the months of April and May with the earliest record being 7 April 1978 at the riding corrals (McIvor and McIvor 1980), and the latest record being 30 May 1968 at Stoney Creek (Gordon 1975).

In Jasper it has been recorded only twice; a female on 26 June 1978 in the Whirlpool River valley (DJH), and a male on 11 July 1979 at the Jasper sewage lagoon (DJH).

There is one breeding record of this species: a female with five young was seen near the beaver ponds on Forty Mile Swamp on 3 July 1978 (MED), but pairs were recorded several times in Banff.

HABITAT

The Wood Duck occurs in ponds and backwaters in the montane and lower subalpine ecoregions. Beaverponds, slow moving streams, and small ponds and marshes with partially wooded margins are the favoured habitats of this species.

REDHEAD *Aythya americana* **REDH**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: very rare visitor
Autumn: very rare migrant
Winter: not recorded

The Redhead breeds in the Great Plains and western mountain basins, and the western boreal forest region (Godfrey 1966). The species breeds locally throughout Alberta except in the mountains (Salt and Salt 1976).

In Banff and Jasper the Redhead occurs most regularly in the lower Bow River and lower Athabasca River valleys.

Spring migration is during late April and May. Earliest record is 16 April 1969 on Talbot Lake (Loewen 1970). Maximum recorded count is 6, on several occasions. A pair

remained on Pocahontas Ponds until 11 June 1980 but did not nest. There is a single autumn record of one male on 14 October 1967 on Lake Minnewanka.

HABITAT

The Redhead frequents large ponds and lakes in the montane ecoregion. The species is usually seen in relatively shallow water adjacent to sedge or reed beds, but also occurs well out in deep water.

RING-NECKED DUCK *Aythya collaris* **(B)** **RIDU**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: fairly common resident
Autumn: fairly common migrant
Winter: not recorded

The Ring-necked Duck is a North American species that breeds throughout much of the boreal and temperate regions of Canada and the northern U.S.A. (Godfrey 1966). The species breeds in the northern half of Alberta and locally in the mountains (Salt and Salt 1976).

In Banff the Ring-necked Duck is a fairly common spring and autumn migrant and breeding species. In Jasper it is a fairly common spring and uncommon autumn migrant and an uncommon breeding species. It is commonest in the lower Athabasca River, lower Bow River, and other low-elevation valleys.

Spring migration is during April and May. Earliest record is 9 April 1977 at Vermilion Lakes. Maximum recorded count is 44 on 26 April 1977 on Vermilion Lakes.

There are nine breeding records since 1976; 1 from Edna Lake, 1 from a backwater pond of the lower North Saskatchewan River, and the rest from the Bow River valley. Earliest recorded brood is 16 June 1978 in the lower North Saskatchewan River valley.

Autumn migration lasts from August until late October. Maximum recorded count is 41 on 29 September 1977 in the lower Bow River valley. Latest record is 12 October 1975 at Vermilion Lakes (Bow Valley Naturalists 1978).

HABITAT

The Ring-necked Duck occurs in lakes and ponds in the montane (48 of 61 records) and lower subalpine (11 records) ecoregions and, rarely, the upper subalpine ecoregion (2 records). Muskeg ponds and shallow waterbodies with emergent sedge vegetation are favoured by this species.

CANVASBACK *Aythya valisineria* **CANV**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: not recorded
Autumn: uncommon migrant
Winter: not recorded

The Canvasback breeds throughout much of the Great Plains region and the inter-montane valleys of western North America (Godfrey 1966). It breeds throughout Alberta except in the mountains and extreme north (Salt and Salt 1976).

In Banff and Jasper this species has been recorded only in the lower Bow River and lower Athabasca River valleys.

Spring migration is during April and May. Earliest record is 9 April 1968 on Talbot Lake (Loewen 1970). Maximum recorded count is 10 on 12 May 1977 on Vermilion Lakes (Bow Valley Naturalists 1978). Latest spring record is 1 June 1967.

There are only 2 autumn records of Canvasbacks. Earliest and maximum recorded count is 36 on 24 September 1977 in the lower Athabasca River valley. Latest record is 12 November 1978 at Vermilion Lakes (McIvor and McIvor 1980).

HABITAT

The Canvasback occurs in lakes and ponds in the montane ecoregion. Extensive beds of sedges and cattails with bays and channels are favoured habitat for this species, which also forages in open water.

LESSER SCAUP *Aythya affinis* **(B)** **LESC**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: uncommon resident
Autumn: fairly common migrant
Winter: not recorded

The Lesser Scaup is a North American species that breeds throughout most of the interior northwestern part of the continent (Godfrey 1966). It breeds throughout Alberta but is only locally distributed in the prairies (Salt and Salt 1976).

In Banff and Jasper Lesser Scaups occur in most of the major valleys, being commonest in the lower Athabasca River, lower Bow River, lower North Saskatchewan River and Snake Indian River valleys.

Spring migration is during April and May. Peak migration is the first two weeks of May. Earliest record is 29 March 1978 at Vermilion Lakes. Maximum recorded count is 78 on 6 May 1978 at Vermilion Lakes.

There are 6 breeding records from Banff and Jasper. Earliest recorded nest is 25 July 1978 beside the upper North Saskatchewan River. Earliest recorded young were hatched from the above nest on 26 July 1978.

Autumn migration lasts from August until freeze-up in late October. Maximum recorded count is 38 on 26 October 1977 at Pyramid Lake. Latest record is 19 November 1968 at Talbot Lake (Loewen 1970).

HABITAT

Lesser Scaup occur in lakes and ponds in the montane and lower subalpine ecoregions. Small forest ponds, beaverponds, floodplain ponds and backwaters, and lake edges are all frequented by Lesser Scaup, providing adequate cover is available in the form of emergent sedge beds or flooded willows.

COMMON GOLDENEYE *Bucephala clangula* **COGO**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: not recorded
Autumn: rare migrant
Winter: common resident

The Common Goldeneye is found in most of the northern parts of Europe, Asia and North America. It breeds throughout the boreal and aspen parkland portions of Alberta.

In Banff and Jasper Common Goldeneyes are most regularly seen along the Bow River and Athabasca River, but have been recorded once in the lower Cascade River and Southesk River valleys.

Spring migration is from mid March to early May. Peak migration is mid to late April. Maximum recorded count is 78 on 22 April 1976 along the lower Athabasca River. Latest spring record is 16 May 1976 in the lower Athabasca River valley.

Autumn migration is during September and October. Earliest autumn record is 23 August 1978 at Talbot Lake. Maximum recorded count is 120 on 29 October 1977 in the lower Athabasca River valley.

Common Goldeneyes regularly winter in Banff on the Bow River and Cave and Basin swamp, and in Jasper at Mile 18 Pond and the lower Athabasca River. From 3 to 87 have been recorded on every Banff Christmas bird count (1960-1962, 1974-1980).

HABITAT

Common Goldeneyes frequent lakes and rivers in the montane ecoregion. They are usually found in deep, open water or along shorelines and the edges of sedge beds.

BARROW'S GOLDENEYE *Bucephala islandica* (B) **BAGO**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: fairly common resident
Autumn: fairly common migrant
Winter: rare resident

The Barrow's Goldeneye is a North American species that breeds in the western Cordillera and along the north Atlantic Coast. In Alberta the species occurs in the mountains and high foothills.

In Banff and Jasper the Barrow's Goldeneye is widespread, occurring in all the major drainages (Figure 3.11, 3.12).

Spring migration is during April and May. Peak migration is late April and early May. Earliest record is 1 April 1976 at Vermilion Lakes (Bow Valley Naturalists 1978). Maximum recorded count is 71 in the lower Athabasca River valley.

This species breeds throughout Banff and Jasper. Earliest recorded young are 7 June 1978 at Snaring Lake.

Autumn migration lasts from August until freeze-up in early November. Maximum recorded count is 33 on 15 October 1977 in the lower Athabasca River valley. Latest record is 9 November 1978 in the lower Athabasca River valley.

Barrow's Goldeneye occasionally winter in Banff. One was recorded on the 1976 Banff Christmas bird count, 21 on the 1980 count (20 December) a pair on 30 June 1965 and six on 11 Febraury 1968. None have been recorded in Jasper in winter.

HABITAT

Barrow's Goldeneyes occur in lakes and ponds in the montane, lower subalpine and upper subalpine ecoregions. Small ponds, including beaverponds, having sedge beds for cover and adjacent forest are favoured by Barrow's Goldeneyes. A plentiful supply of standing dead trees in or near such ponds is also important since this species nests in abandoned woodpecker holes. Migrating goldeneyes are often seen on deeper, more open water bodies.

BUFFLEHEAD *Bucephala albeola* **BUFF**

STATUS AND DISTRIBUTION

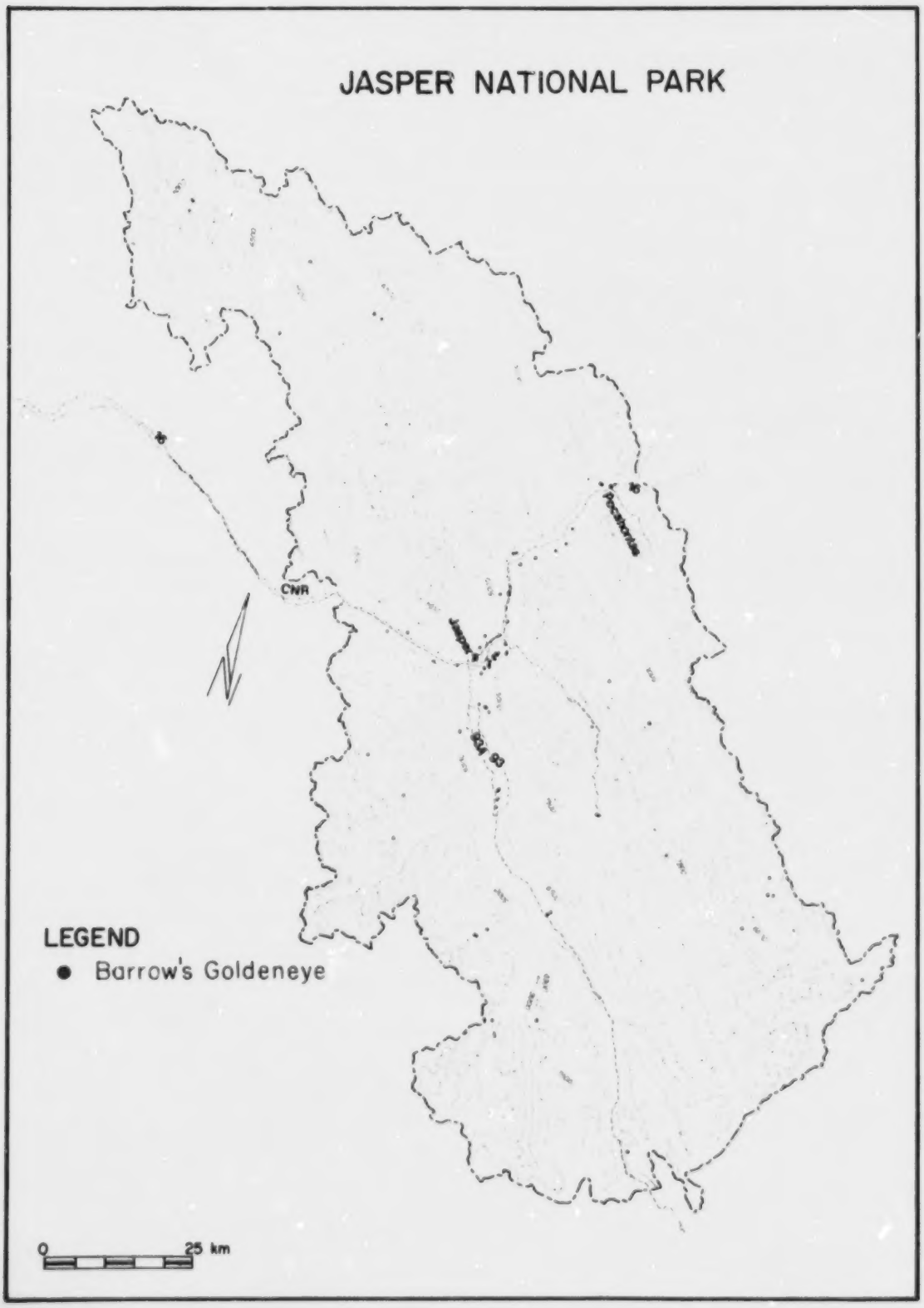
Spring: fairly common migrant
Summer: uncommon visitor
Autumn: uncommon migrant
Winter: very rare resident

The Bufflehead breeds in Alaska and northern Canada west of northern Ontario (Godfrey 1966). It breeds throughout Alberta except in the prairies (Salt and Salt 1976).

In Banff and Jasper Buffleheads are seen regularly on Talbot Lake, Vermilion Lakes, and other lakes in the lower Athabasca River, lower Bow River and lower North

Figure 3.11. Distribution of Barrow's Goldeneye observations in Banff.

Figure 3.12. Distribution of Barrow's Goldeneye observations in Jasper.



Saskatchewan River valleys.

Spring migration is during April and May. Peak migration is late April and early May. Earliest record is 9 April 1968 at Talbot Lake (Loewen 1970). Maximum recorded count is 95 on 6 May 1979 at Talbot Lake.

Although pairs of Buffleheads are seen occasionally during the breeding season, no nests or broods have been recorded. There is one breeding record from Kootenay National Park.

Autumn migration lasts from late September until freeze-up in early November. Earliest autumn record is 26 September 1978 at Talbot Lake. Maximum recorded count is 180 on 15 October 1978 in the lower Athabasca River valley. Latest autumn record is 15 November 1969 at Pocahontas Ponds (Loewen 1970).

Buffleheads occasionally remain until late winter on the Bow River near Banff; there are single records from the Banff Christmas bird counts of 1961 and 30 December 1978.

HABITAT

The Bufflehead frequents ponds and lakes in the montane and lower subalpine ecoregions. During breeding season Buffleheads are most often seen on small ponds in coniferous forest and in sheltered bays of larger lakes. On migration flocks gather on open water of lakes and rivers.

This species nests in abandoned woodpecker holes and is consequently dependent on dead, standing trees near water for nest sites.

OLDSQUAW *Clangula hyemalis* **OLDS**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: not recorded
Autumn: not recorded
Winter: not recorded

The Oldsquaw breeds in arctic regions of the Northern Hemisphere (Godfrey 1966). The species is a regular spring migrant in the northern half of Alberta, occurring less regularly farther south (Salt and Salt 1976).

In Banff Oldsquaws are rare spring migrants; in Jasper they are uncommon spring migrants. They are seen most regularly on Pyramid, Patricia, and Talbot Lakes. In Banff there are two records from Vermilion Lakes and four Oldsquaws were collected in 1916 near Banff townsite (Clarke and Cowan 1945).

Spring migration is during April and May. Peak migration is mid-May. Earliest record is 11 April 1978 at Talbot Lake. Maximum recorded count is 35 on 11 May 1979 on Talbot Lake. Latest spring record is 14 May 1977 at Edith Lake. In Banff and Jasper, as in the rest of Alberta (Salt and Salt 1976), there is no autumn migration of Oldsquaws.

HABITAT

Oldsquaws frequent deep lakes in the montane ecoregion.

HARLEQUIN DUCK *Histrionicus histrionicus* **(B)** **HADU**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: uncommon resident
Autumn: rare migrant
Winter: not recorded

The Harlequin Duck breeds in Siberia, northeastern Europe, Greenland, Baffin Island, Labrador, and the North American cordillera (Godfrey 1966). The species occurs in the Rocky Mountains and high foothills of Alberta (Salt and Salt 1976).

In Banff and Jasper Harlequin Ducks are sparsely distributed in small rivers and streams throughout both parks during the breeding season (Figure 3.13, 3.14). The Bow River below Lake Louise and Athabasca River below Athabasca Falls are major spring staging areas.

Spring migration is during May and June. Peak migration is late May. Earliest record is 2 May 1978 on the Bow River. Maximum recorded count is 42 on 1 June 1977 along the Bow River.

Although no nests have been found, broods of young have been observed at Lick Creek, Hardisty Creek, Astoria River (Chrome Lake), Jacques Lake and Cairn River in Jasper, and four broods have been recorded along the Bow River. Most broods are seen in August; the earliest record is 14 July 1975 on the Bow River.

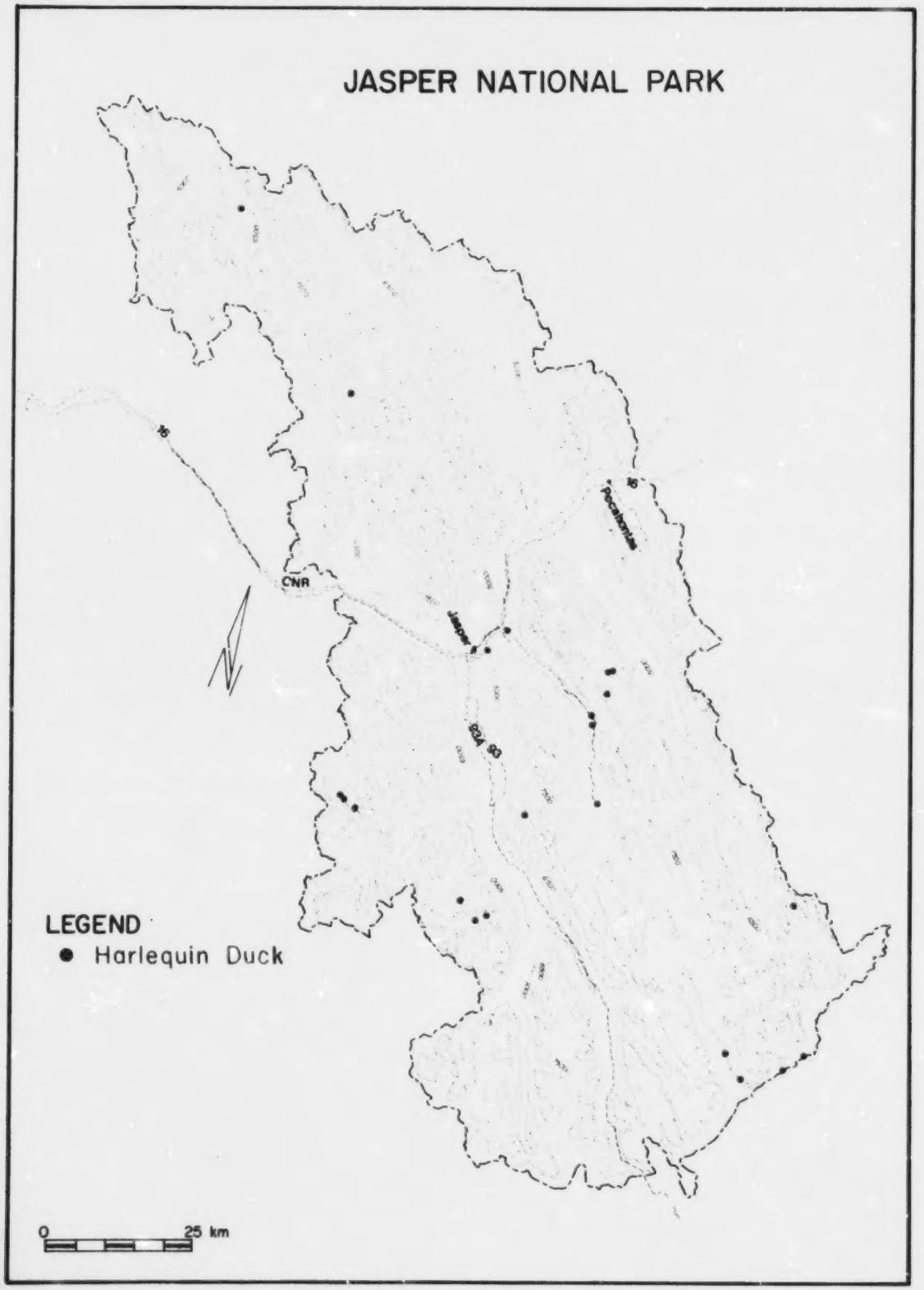
Autumn migration is during August, earlier than other waterfowl. Maximum recorded count is a family group of 7 on 13 August 1978 on the upper Athabasca River. Latest autumn record is 15 September 1981 on the Bow River.

HABITAT

Harlequin Ducks frequent rivers and streams in the montane, lower subalpine and upper subalpine ecoregions. Migrating Harlequin Ducks congregate on gravel bars of large rivers, but during the breeding season they are more commonly seen on fast-flowing, forest-bordered streams. Streams bordered by spruce forest are preferred to those bordered by pine or poplar.

Figure 3.13. Distribution of Harlequin Duck observations in Banff.

Figure 3.14. Distribution of Harlequin Duck observations in Jasper.



WHITE-WINGED SCOTER *Melanitta deglandi* **WHSC**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: uncommon visitor
Autumn: uncommon migrant
Winter: not recorded

The White-winged Scoter breeds in the northwestern part of North America (Godfrey 1966). It breeds throughout Alberta except in the mountains (Salt and Salt 1976).

In Banff and Jasper this species is most frequently seen on Talbot Lake and Vermilion Lakes but has also been recorded on Lake Minnewanka, Waterfowl Lakes (3 records), Bow Lake (1 record) Clearwater Lakes (1 record), and Patricia and Pyramid Lakes.

Spring migration is during May and peaks in late May. Earliest record is 3 May 1978 at Vermilion Lakes. Maximum recorded count is 85 on 15 May 1977 at Disaster Point. Latest spring record is 3 June 1978 at Waterfowl Lakes.

Autumn migration lasts from early August to early October. Earliest autumn record is 8 August 1978 at Talbot Lake. Maximum recorded count is 50 on 14 October 1967 on Lake Minnewanka (Sadler and Myres 1976). Latest record is 18 October 1980.

HABITAT

White-winged Scoters occur on open water on lakes and large ponds in the montane and lower subalpine ecoregions.

SURF SCOTER *Melanitta perspicillata* **SUSC**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: uncommon visitor
Autumn: uncommon migrant
Winter: not recorded

The Surf Scoter breeds in Alaska and northern boreal regions of Canada (Godfrey 1966). It breeds in northern Alberta, possibly as far south as Obed Lake (Salt and Salt 1976).

In Banff and Jasper Surf Scoters are fairly common spring and uncommon autumn migrants, but their occurrence is less regular than that of other species. Sine 1975, they have been seen most frequently on Patricia Lake, Pyramid Lake and Talbot Lake but also on Vermilion Lakes (3 records), Waterfowl Lakes (3 records), Bow Lake, Twintree Lake and Adolphus Lake (1 record each).

Spring migration is during May, peaking in mid-May. Earliest record is 13 May 1952 at Pyramid Lake. Maximum recorded count is 60 on 22 May 1953 at Pyramid Lake (Banfield 1954b).

Surf Scoters rarely remain in Banff and Jasper during the breeding season. A pair remained in the Smoky River valley until at least 9 June 1980 (JLK, GRB) and a male remained on an unnamed lake near North Saskatchewan River Crossing until 5 June 1978,

but there is no evidence that these were breeding.

Autumn migration peaks during October. Earliest autumn record is 2 September 1977 in the lower Athabasca River valley. Maximum recorded count is 25 on 14 October 1967 (Sadler and Myres 1976). Latest record is 9 November 1969 at Pocahontas Ponds (Loewen 1970).

HABITAT

Surf Scoters are usually seen on open, deep water on large ponds and lakes in the montane and lower subalpine ecoregions.

RUDDY DUCK *Oxyura jamaicensis* **RUDU**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: very rare visitor
Autumn: rare migrant
Winter: not recorded

The Ruddy Duck breeds from Great Slave Lake south through Guatemala to Colombia (Godfrey 1966). It breeds throughout Alberta except in the mountains (Salt and Salt 1976).

In Banff and Jasper Ruddy Ducks are irregular migrants seen occasionally on Vermilion Lakes, Talbot Lake, and other low elevation lakes in the lower Athabasca River and lower Bow River valleys. There is one record from Waterfowl Lakes.

Spring migration is from mid April until late May. Earliest record is 11 April 1979 at Talbot Lake. Maximum recorded count is 30 on 9 May 1977 at Vermilion Lakes. Latest spring record is 9 June 1979 at the Jasper sewage lagoon. There are three breeding season records: a male seen on 3 June 1978 at Waterfowl Lakes; a female seen on 9 June 1979 at the Jasper sewage lagoon; and four seen on 21 July 1978 at Vermilion Lakes (T. Lang, pers. comm.).

Autumn migration lasts from August until late October but is very irregular. Earliest autumn record is 12 August 1977 at Vermilion Lakes. Maximum recorded count is 16 on 15 October 1977 in the lower Athabasca River valley. Latest record is 29 October 1977 at Talbot Lake.

HABITAT

Ruddy Ducks frequent the edges of sedge beds or reeds, or bays and channels that punctuate beds of emergent vegetation in ponds and lakes in the montane ecoregion. There is a single record from the lower subalpine ecoregion.

HOODED MERGANSER *Lophodytes cucullatus* **HOME**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon visitor
Autumn: fairly common migrant
Winter: not recorded

The Hooded Merganser breeds thoughout southern Canada and the northern continental United States except the prairies region (Godfrey 1966). In Alberta the species is a regular migrant and possibly breeds in the northern part of the province (Salt and Salt 1976).

In Banff and Jasper Hooded Mergansers are seen regularly in the lower Athabasca River and Bow River valleys, and have not been recorded elsewhere.

Spring migration is during mid April and May. Earliest record is 9 April 1977 at Vermilion Lakes. Maximum recorded count is 9 on 11 April 1979 at Talbot Lake. Latest spring record is 30 May 1977 at Vermilion Lakes.

Although Macoun (1904) considered this to be a breeding species in Banff, there are no records of nests or young in Banff or Jasper.

Autumn migration lasts from August to freeze-up in early November. Peak migration is late September. Earliest autumn record is 27 July 1979 at Jasper sewage lagoon. Maximum recorded count is 18 on 27 September 1977 at Vermilion Lakes. Latest record is 8 November 1978 at Talbot Lake.

HABITAT

Ponds and lakes in the montane and lower subalpine ecoregions are favoured areas for Hooded Mergansers, especially where there is shelter in the form of beds of emergent sedges or reeds, or flooded willows.

COMMON MERGANSER *Mergus merganser* **(B)** **COME**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: uncommon resident
Autumn: fairly common migrant
Winter: very rare visitor

The Common Merganser breeds throughout much of the temperate and boreal regions of the Northern Hemisphere. It nests throughout Alberta except in the prairies.

In Banff and Jasper this species frequents the larger rivers such as the lower Bow River, Red Deer River, Clearwater River, Brazeau River, Sunwapta River, Athabasca River, Miette River and Snake Indian River. Very rarely it winters on open water on the lower Bow River. The lower Bow River and Athabasca River are major spring staging areas for the species

Spring migration is during April and May, peaking in early and mid April. Earliest record is 24 March 1979 on the Bow River. Maximum recorded count is 30 on 17 April 1976 in the lower Athabasca River valley.

No nests have been recorded but broods have been observed in both Banff and Jasper. Earliest recorded young are 23 June 1972 on the Snake Indian River (Carbyn 1972a).

Autumn migration lasts from September until freeze-up in November. Peak migration is early October. Maximum recorded count is 80 on 10 October 1978 and 15 October 1979 along the lower Athabasca River valley. Latest record is 23 November 1969 on the lower Athabasca River (Loewen 1970).

Common Mergansers are very rare in winter; one was recorded on the 1978 Banff Christmas bird count (17 December) and 2 and 1 were recorded on 29 January and 16 December 1979 respectively on the lower Athabasca River.

HABITAT

Common Mergansers are usually seen on gravel bars or close to wooded shores on large rivers and deep lakes in the montane and lower subalpine ecoregions. Standing dead trees in such areas are important to this species as abandoned woodpecker holes are used as nest sites.

RED-BREASTED MERGANSER *Mergus serrator* **REME**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: not recorded
Autumn: very rare migrant
Winter: not recorded

The Red-breasted Merganser breeds throughout most of the arctic and boreal regions of the Northern Hemisphere (Godfrey 1966). In Alberta the species is a migrant throughout the province and apparently breeds only in the northeastern corner (Salt and Salt 1976).

In Banff and Jasper Red-breasted Mergansers have been observed only in the lower North Saskatchewan River valley and at Vermilion Lakes, Banff townsite, Edith Lake, and Talbot Lake.

Spring migration is in May. Earliest record is 29 April 1976 at Vermilion Lakes. Maximum recorded count is five on 8 May 1946 at Vermilion Lakes (Jasper warden cards). Latest spring record is 8 June 1978 on the lower North Saskatchewan River.

There are only three records of this species during autumn migration: six on 8 October 1967 in Banff, two individuals on 28 October 1978 at Talbot Lake and three on 8 November 1978 at Talbot Lake.

HABITAT

Lakes and rivers in the montane and lower subalpine ecoregions are prefered by Red-breasted Mergansers, which are usually seen along wooded shores or in flooded willow shrubbery, but occasionally well out in open water.

TURKEY VULTURE *Cathartes aura* **TUVU**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Turkey Vulture occurs throughout most of the temperate and tropical portions of North and South America (Godfrey 1966). The species was formerly more common in Alberta but still nests locally in the prairie region and north as far as Ashmont (Salt and Salt 1976).

There is only a single record of this species in Banff. Macoun (1904) reported one during the summer of 1891. A pair may have nested in the Wildcat Hills east of Banff in 1966 (Sadler and Myres 1976) but it is unlikely that this species would occur in the Rocky Mountains except as an occasional migrant.

GOSHAWK *Accipiter gentilis* **(B)** **GOSH**

STATUS AND DISTRIBUTION

Spring: rare resident
Summer: rare resident
Autumn: rare resident
Winter: very rare resident

The Goshawk nests in wooded parts of North America, Europe and Asia (Godfrey 1966). It occurs throughout northern and western Alberta and in the Cypress Hills (Salt and Salt 1976).

In Banff and Jasper 24 of 32 records since 1975 are from the valleys of the Front Ranges. Maximum recorded count is three.

Earliest recorded nest is 12 July 1979 in the Bow River valley. Earliest recorded young are 18 July 1943 in the Little Pipestone valley (Clarke and Cowan 1945). Fledged young were seen on 23 July 1978 in the lower North Saskatchewan River valley.

HABITAT

Goshawks frequent forested areas in the montane and lower subalpine ecoregions and, to a much lesser extent, the upper subalpine ecoregion. They prefer alluvial fans and steep slopes with open coniferous or deciduous forest, or forests with patches of meadow or adjacent meadows. They often hunt by soaring along open valley slopes.

LIFE HISTORY

Predation or attempted predation has been observed on Columbian ground squirrel (twice), Varying hare (once), Spruce Grouse (once), Black-billed Magpie (once) and Gray Jay (once) in Banff and Jasper.

SHARP-SHINNED HAWK *Accipiter striatus* **(b)** **SHHA**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: very rare resident

The Sharp-shinned Hawk breeds from Alaska and northern Canada south to the Gulf Coast (Godfrey 1966). In Alberta it occurs throughout the wooded areas of the province (Salt and Salt 1976).

In Banff and Jasper 30 of 47 observations of this species since 1975 are from the valleys of the Front Ranges, but Sharp-shinned Hawks occur throughout both parks, particularly during autumn migration.

Spring migration is during late April and early May. Earliest record is 17 April 1909 at Banff (Clarke and Cowan 1945). No more than two have been recorded on any occasion.

There are no nest records but recently-fledged young were observed on 13 August 1979 in the Clearwater River valley.

Autumn migration lasts from August until mid October. Maximum recorded count is one on all occasions. Latest record is 16 October 1979, in the lower Cascade River valley.

There is one winter record: two were seen on the 1977 Banff Christmas bird count.

HABITAT

This species frequents forested areas in the montane and lower subalpine ecoregions, and upper subalpine and alpine ecoregions during migration. Sharp-shinned Hawks occur on a variety of landforms, preferring open forests, deciduous forests or tall shrubbery, and forests with patches of meadow or adjacent meadows. On autumn migration Sharp-shinned Hawks may be seen soaring above open slopes, avalanche tracks, or timberline areas, and most records from the Main Ranges are from the autumn migration period.

LIFE HISTORY

Predation has been observed on Least chipmunk (once) and Pine Siskin (once) in Banff and Jasper.

COOPER'S HAWK *Accipiter cooperi* **(B)** **COHA**

STATUS AND DISTRIBUTION

Spring: rare resident
Summer: rare resident
Autumn: rare resident
Winter: very rare visitor

The Cooper's Hawk breeds throughout most of the temperate and sub-tropical regions of North America (Godfrey 1966). The breeding distribution of the species in Alberta corresponds roughly to the Rocky Mountains and parkland region (Salt and Salt 1976).

In Banff and Jasper 26 out of 39 records of this species since 1975 were in the major valleys of the Front Ranges.

Spring migration is in May. Earliest record is 2 May 1977 in the Bow Valley. Maximum recorded count is one.

There is only one nesting record: a pair at a nest in July 1976 near Kerkeslin Creek in Jasper (GLH).

Autumn migration lasts from August until early October. Maximum recorded count is five on 2 September 1979 in the Sunwapta valley. Latest recorded departure is 1 October 1977 in the Cascade fire road valley.

There is only one winter record: two were observed on the 1977 Banff Christmas Bird Count.

HABITAT

Cooper's Hawks frequent forested areas in the montane and lower subalpine ecoregions. They occur primarily on alluvial fans, and to a lesser extent on steep slopes, in lodgepole pine, poplar, or mixed woodland especially where there are openings or adjacent open areas.

RED-TAILED HAWK *Buteo jamaicensis* **(B)** **REHA**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: uncommon resident
Autumn: rare migrant
Winter: very rare visitor

The Red-tailed Hawk breeds from the northern limit of trees in North America south to Panama (Godfrey 1966). It breeds throughout Alberta (Salt and Salt 1976).

In Banff and Jasper Red-tailed Hawks were formerly more common than they are at present. In 1946 there were four territorial pairs along the lower Athabasca River and Miette River (Jasper warden cards), yet only one nest was found in this area during the course of the wildlife inventory. Although Red-tailed Hawks have been recorded in most parts of Banff and Jasper, 31 of 56 observations were from the Athabasca River and Bow River valleys.

Spring migration is during April and May. Earliest record is 3 April 1976 in the lower Cascade River valley.

Earliest recorded young are 3 July 1975 in the Bow River valley.

Autumn migration is in late August and early September. Latest record is 12 September 1971 at Bryant Creek.

A Red-tailed Hawk observed on the 1980 Banff Christmas bird count (20 December 1980) is the only winter record.

HABITAT

Semi-open areas in the montane and lower subalpine ecoregions are used by the Red-tailed Hawk. Deciduous and mixed forests, especially adjacent to grasslands and shrubby meadows, are favoured, but coniferous forest (22 records) is also used.

BROAD-WINGED HAWK *Buteo platypterus* **BRHA**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Broad-winged Hawk breeds in deciduous woodland regions from Canada's aspen parkland areas south to Florida and the West Indies (Godfrey 1966). In Alberta the species breeds in the aspen parkland and mixed-wood forest in the central part of the province (Salt and Salt 1976).

In Banff this species is very rare; there are only two records, both of which may represent the same individual. One was seen in the upper Spray valley on 28 June 1977, and on 29 August 1977 one was seen in the lower Bow River valley (MED). There are no records from Jasper.

HABITAT

The Broad-winged Hawk typically frequents "... deciduous groves or the more open parts of mixed-wood forests" (Salt and Salt 1976). Both Banff records were in wooded alluvial areas.

ROUGH-LEGGED HAWK *Buteo lagopus* **ROHA**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: very rare visitor
Autumn: rare migrant
Winter: very rare visitor

The Rough-legged Hawk breeds in arctic regions of North America, Russia and Scandinavia (Godfrey 1966). It is a regular migrant throughout Alberta and occasionally winters on the prairies (Salt and Salt 1976).

In Banff and Jasper this species is a very rare migrant. Between 1978 and 1980 there were ten records in the lower Athabasca River, three in the Bow River valley, and one in the Clearwater River valley.

There are only two records during spring migration: one on 22 April 1979 at Jasper's east gate and one was seen in the Bow River valley on 27 May 1977 (MED), about a month after most Rough-legged Hawks have left the province (Salt and Salt 1976).

There is a single record during the breeding season: an individual seen on 17 June 1979 in the Clearwater River valley (HFC).

Autumn migration is during November and December. Earliest record is 18 October 1980 in the lower Athabasca River valley. Maximum recorded count is one. Latest record is 1 January 1979 in the lower Athabasca River valley.

Rough-legged Hawks do not usually winter in Banff and Jasper. An individual that spent at least the first half of the winter of 1978/79 west of Hinton occasionally hunted in Jasper as far west as Jacques Creek, and another was seen in the winter of 1980/81 between Banff townsite and Canmore.

HABITAT

Rough-legged Hawks prefer frozen marshes, grasslands, shrubby meadows and open forests. Nine of 11 observations since 1975 were in the montane ecoregion, and all were on or near large river floodplains.

SWAINSON'S HAWK *Buteo swainsoni* **SWHA**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Swainson's Hawk breeds primarily in the Great Plains region and also in the interior valleys of the Western Cordillera (Godfrey 1966). It breeds in the prairie and aspen parkland regions of Alberta (Salt and Salt 1976).

In Banff and Jasper it is very rare, there are only seven records. A specimen was collected near Banff in 1913 (Clarke and Cowan 1945). Individuals were seen on 8 May 1979 in the Mistaya valley (KVT), on 3 and 18 June 1977 in the Bow River valley (MED), on 13 June 1978 in the Miette River valley (DJK), on 23 June 1978 at the Big Hill and on 26 May 1979 near Jasper (KVT).

This species may formerly have occurred more regularly than at present. Clarke and Cowan (1945) described the Swainson's Hawk as a "... summer visitant, not common... and is seen regularly at the Yaha Tinda Ranch."

HABITAT

The Swainson's Hawk has occurred in grasslands and along cleared highway rights-of-way in the montane and lower subalpine ecoregions in Banff and Jasper. The usual habitat of the species is "open, dry country... plains, prairies, dry mountain valleys and foothills... " (Godfrey 1966).

FERRUGINOUS HAWK *Buteo regalis* **FEHA**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Ferruginous Hawk breeds in the Great Plains region of North America (Godfrey 1966). In Alberta this species "... formerly nested commonly in the prairie regions... particularly along river valleys and coulees... The Ferruginous Hawk occupies much the same range today but in greatly diminished numbers" (Salt and Salt 1976).

In Banff and Jasper this species is a very rare visitor; there are only three records. "There is a specimen in Banff Museum... from Banff" (Clarke and Cowan 1945) and there is a record of an individual at North Saskatchewan River Crossing on 17 May 1974 (Gordon 1975). The possibility that this species may formerly have nested in Jasper is suggested by the observation of two agitated adults on 9 July 1944, five miles east of Brazeau Lake (Cowan 1955).

Ferruginous Hawks are becoming increasingly uncommon in Alberta and it is unlikely that they will occur in Banff and Jasper except, possibly, as occasional migrants.

HABITAT

Habitat data is available only for Cowan's 1944 record, which he describes as "... a treacherous canyon... ". The usual habitat of the Ferruginous Hawk is "... the steep, clay cliffs of the badlands... " of the southern prairies (Salt and Salt 1976).

GOLDEN EAGLE *Aquila chrysaetos* **(B)** **GOEA**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: fairly common migrant
Winter: rare resident

The Golden Eagle breeds throughout North America, Europe and Asia and part of northern Africa (Godfrey 1966). It breeds locally throughout Alberta, being most common in the mountains and foothills (Salt and Salt 1976).

In Banff and Jasper this species is less abundant now than formerly. Although it occurs throughout both parks only 14 nesting territories were identified between 1975 and 1980 (Figure 3.15, 3.16). In Banff it was "... widely distributed and may be observed in most parts of the park... " in the 40's (Clarke and Cowan 1945). In Jasper it was considered "... fairly common and widely distributed... " (Cowan 1955).

Spring migration is during April and May. Peak migration is early April. Maximum recorded count is four on 7 and 8 March 1972 at Cairn Pass (Jasper warden cards).

Earliest recorded nest is 27 May 1978 in the North Saskatchewan River valley. Earliest recorded young are 8 June 1965 at Poboktan Creek (Jasper warden cards).

Autumn migration is from September until mid November. Peak migration is early and mid October. Maximum recorded count is nine on 12 October 1975 in the Cascade fire road valley.

There are several records of Golden Eagles remaining in Banff and Jasper during the winter. Most are in the Athabasca River valley with fewer in the Bow Valley.

HABITAT

During the breeding season Golden Eagles occur mostly in open and semi-open habitats in the alpine, upper subalpine and lower subalpine ecoregions. The montane ecoregion is used primarily during migration and winter.

Golden Eagles nest on cliff faces, generally with southerly exposures. Their hunting encompasses a wide range of habitats but they are seen most commonly on semi-open mountain slopes, avalanche paths and alpine meadows. During migration and winter, when carrion becomes an important food source, they concentrate in the low valleys where ungulates are most abundant.

LIFE HISTORY

In Banff and Jasper there are records of Golden Eagles preying on Columbian ground squirrel (once), Canada Goose (once), Mallard (twice) and unidentified duck (twice). Attempted predation has been observed on sheep (once), goat (once), and Hoary marmot (once). Golden Eagles have been observed scavenging on carcasses of sheep (5 times), moose (once), elk (3 times), and coyote (3 times). Some of these records may have represented predation. Warden Frank Camp reported one eagle dead at a poisoned carcass on 15 March 1953 in the middle Athabasca River valley (Jasper warden cards).

A food habits breakdown for Golden Eagles in North America, using all available literature, was prepared by Olendorff (1976). If adjustments are made to exclude food sources not available in Banff or Jasper, the following breakdown applies to our area:

Figure 3.15. Distribution of Bald and Golden Eagle and Osprey observations in Banff.

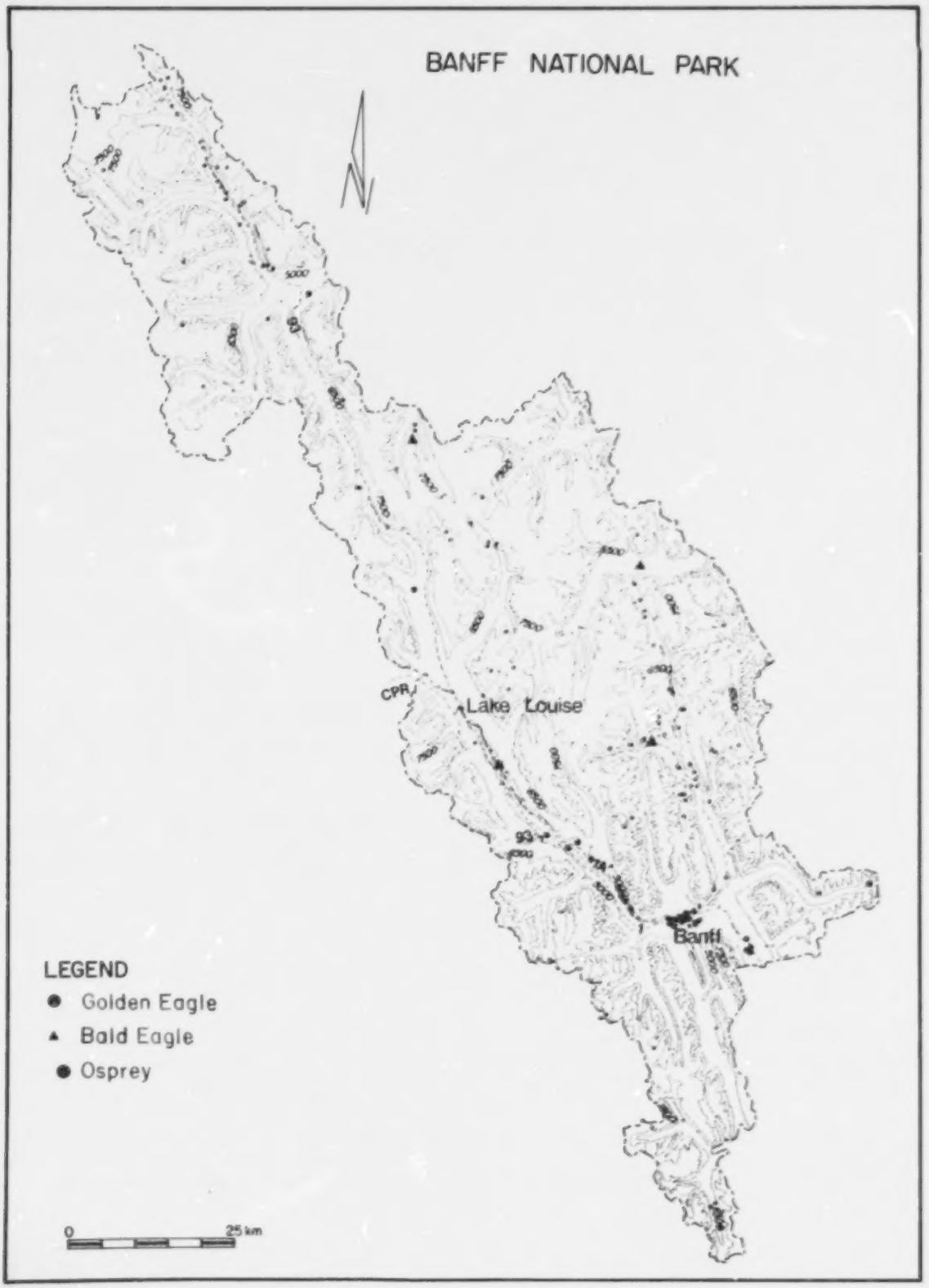
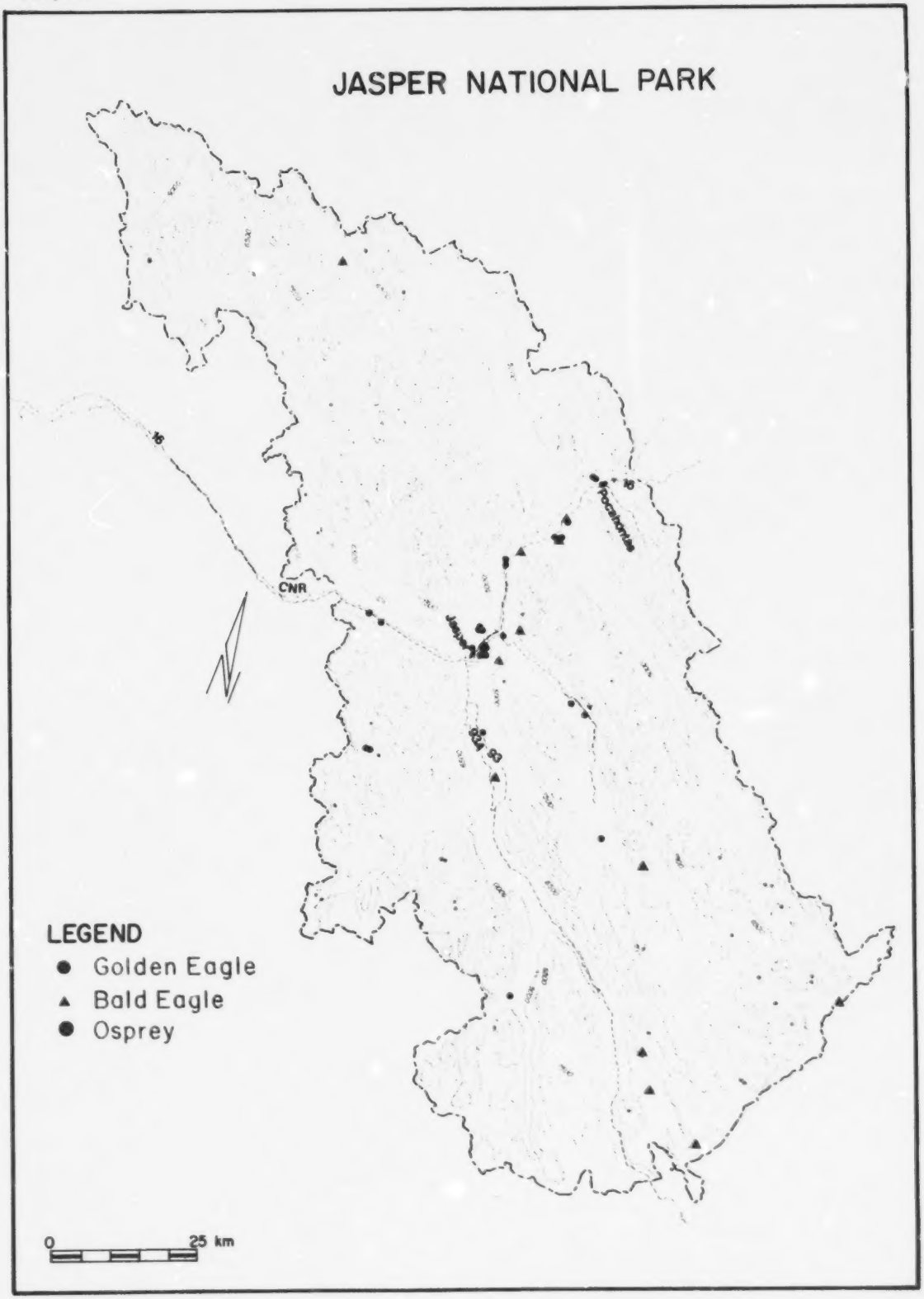


Figure 3.16. Distribution of Bald and Golden Eagle and Osprey observations in Jasper.



short-tailed weasel	0.1%	Long-tailed weasel	3.7%	American badger	0.1%
striped skunk	4.3%	coyote	0.7%	Hoary marmot	6.3%
ground squirrel	42.2%	chipmunks	0.1%	Bushy-tailed wood rat	1.2%
voles	8.1%	muskrat	2.9%	unidentified rodent	2.2%
Varying hare	1.0%	deer	23.7%	Bighorn sheep	3.1%

Ground squirrels, voles and marmots represent more than half the diet of Golden Eagles by this analysis and if it can be assumed that a large proportion of that part of the diet represented by deer involves road and winter kills which are used primarily by migrating and wintering birds, then diurnal rodents are probably of much greater importance during the breeding season. It can be anticipated that accessible colonies of ground squirrels and marmots in areas having low human activity are highly important to breeding Golden Eagles.

The aspect of nest sites are variable but are usually on ledges on steep cliffs of a southerly aspect in the subalpine ecoregions. Of 12 nest sites in Banff and Jasper for which adequate data exists, only two face due east and one due west; the remainder have southerly orientations. Six are in the upper subalpine ecoregion, five in the lower subalpine ecoregion, and one in the montane ecoregion. There is an undocumented record of one nest in the alpine ecoregion on the southern boundary of Banff.

Nests are not used consistently from one year to the next and may be permanently abandoned after one or two seasons of use. Causes of abandonment are not always clear but excessive human disturbance in the vicinity of the nest will cause nest failure and abandonment (Fyfe and Olendorff 1976).

Breeding densities are generally low throughout Banff and Jasper but they can be relatively high in areas with favorable habitat and prey concentrations as indicated by Warden Toni Klettl's record of two active nests in the Tonquin Valley in 1966 (Jasper warden cards). This area of extensive herb and heath meadows supports large populations of voles and Columbian ground squirrels.

MANAGEMENT CONSIDERATIONS

Golden eagles are highly susceptible to disturbance at their nest sites, particularly early in the nesting period (Fyfe and Olendorff 1976). They are also much sought-after by falconers. Locations of all known nest sites should be kept classified to protect nesting eagles from harassment by photographers and falconers. Climbers are likely to avoid eagle nests for their own safety; nonetheless, climbers registering for climbs should be told of their potential impact on nesting raptors.

Colonies of Columbian ground squirrels and Hoary marmots are valuable food sources for eagles and should be protected from development and disturbance. Eagles are highly vulnerable to poisoning with canid poisons at carcasses; broad-cast poisoning of carnivores should be monitored on areas adjacent to the parks and discouraged during the migratory and breeding period of eagles. Banff and Jasper's eagles have probably declined more as a consequence of habitat loss, poisoning and hunting outside the parks than inside them. The wintering locations of eagles and other species that leave the parks should be identified by a banding program to identify potential management problems related to land and wildlife management outside the parks.

BALD EAGLE *Haliaeetus leucocephalus* **(B)** **BAEA**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: rare resident
Autumn: uncommon migrant
Winter: rare resident

The Bald Eagle breeds locally throughout the forested regions of North America but is most common in coastal regions (Godfrey 1966). In Alberta the species "... formerly nested... even occasionally on the prairies, but today it is confined to the Rocky Mountains and the northern half of Alberta... " (Salt and Salt 1976).

In Banff and Jasper Bald Eagles occur mainly in the large montane valley bottoms of the lower Athabasca River, lower Bow River, and middle Bow River (Figure 3.15, 3.16). Of 50 observations recorded during the inventory, 35 were in the above valleys, only three records are from the Main Ranges.

Spring migration is from mid March until May. Peak migration is early April. Earliest record is 18 March 1972 at Talbot Lake (Jasper warden cards). Maximum recorded count is four on 31 March 1967 at Talbot Lake (Jasper warden cards).

There is only one recent nest site in Banff or Jasper, at Vermilion Lakes. It was used from 1973 to 1979 but not in 1980. In 1981 Bald eagles nested at Vermilion Lakes again and another pair nested near Exshaw, east of Banff. Bald eagles nested on an island in the lower Athabasca River (Jasper warden cards) in 1942, at the Maligne horse range in 1946 (Cowan 1955) and at Talbot Lake from 1972 to 1974 (Jasper warden cards). Earliest recorded nesting is 25 March 1977 at Vermilion Lakes. Earliest recorded young are 5 June 1946 at the Maligne horse range (Cowan 1955).

Autumn migration lasts from September until November. Peak migration is October. Maximum recorded count is four on 4 November 1972 at Talbot Lake (Jasper warden cards). Latest record is 26 November 1975 at Talbot Lake (Jasper warden cards).

Bald eagles occasionally remain in Banff and Jasper during the winter. Individuals were observed on the 1975, 1978 and 1979 Banff Christmas bird counts, on 9 February 1977 over Banff townsite, on 23 February 1967 feeding on a sheep carcass at Windy Point in Jasper, on 26 February 1971 feeding on an elk carcass at Talbot Lake and one wintered near Talbot Lake during 1978/79.

HABITAT

Bald Eagles occur near lakes, rivers and open areas in the montane and lower subalpine ecoregions. They nest in large trees, usually white spruce or Douglas-firs, near large rivers, lakes, or alluvial wetlands. During breeding season they hunt mostly in wetlands and along the shores of waterbodies, but during migration and winter they frequent a variety of open and semi-open habitats where they scavenge dead ungulates.

LIFE HISTORY

Predation has been recorded on coot (once) and unidentified fish (twice). Two unsuccessful attacks on sheep have been recorded, and Bald Eagles have been observed feeding on carcasses, probably carrion, of sheep (twice), coyote (once), elk (six times), and deer (once).

Bald Eagles compete with ospreys for nest sites and food, and have been observed stealing both. Warden Norm Young has observed Bald Eagles feeding on carrion

with Golden Eagles and being chased from carrion by Golden Eagles (Jasper warden cards).

MANAGEMENT CONSIDERATIONS

Protection of nest sites from all forms of disturbance, particularly photographers, is critical to the maintenance of this very rare species in Banff and Jasper. rock blasting related highway construction could disturb the nesting eagles at Vermilion Lakes.

MARSH HAWK *Circus cyaneus* **MAHA**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: very rare visitor
Autumn: fairly common migrant
Winter: not recorded

The Marsh Hawk breeds in low arctic, boreal and temperate regions of North America, Europe and Asia (Godfrey 1966). It breeds throughout Alberta (Salt and Salt 1976).

In Banff and Jasper Marsh Hawks occur most regularly in the high creek valleys of the Front Ranges on migration. Of 93 observations since 1975, 71 were in the valleys of the Front Ranges.

Spring migration is during early and mid May. Earliest record is 12 April 1978 at First Vermilion Lake.

Autumn migration lasts from late July until the end of September. Peak migration is in August, when 66 of 93 observations since 1975 were recorded. Earliest record is 29 July 1943 near Brazeau Lake (Cowan 1955). Maximum recorded count is 9 on 9 August 1979 in the Clearwater River valley. Latest record is 27 September 1979 at Vermilion Lakes. Most autumn migrants are immatures.

HABITAT

Open alluvial meadows and wetlands in the montane, lower subalpine and upper subalpine ecoregions and, less commonly, alpine meadows are favoured by Marsh Hawks. They are usually seen hunting over grasslands and stands of *Salix glauca* and dwarf birch (*Betula* spp.) that occur in cold-air drainage ecoregions along subalpine creek valleys, particularly in the Front Ranges.

OSPREY *Pandion haliaetus* **(B)** **OSPR**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: fairly common resident
Autumn: fairly common migrant
Winter: not recorded

The Osprey occurs in the temperate and tropical regions of every continent (Godfrey 1966). The species was formerly found in suitable habitat throughout Alberta but "Today it breeds rarely and locally in central Alberta and more commonly in the north and in the mountains" (Salt and Salt 1976).

In Banff and Jasper Ospreys are confined to rivers and lakes large enough to sustain sizeable fish populations (Figure 3.15, 3.16). Of twelve known nest sites in Jasper since 1970, ten are in the lower Athabasca River valley and the remaining two are at Medicine and Maligne Lakes. Ospreys seen occasionally at Amethyst Lake and frequently along the Miette River probably nest along the Miette River but no nests have been recorded there recently. In Banff there are six territories in the Bow River valley that have been used most years since 1970 according to warden E. Carleton.

Spring migration is in April and May. Peak migration is May. Earliest record is 11 March 1971 in the lower Athabasca River valley (Jasper warden cards). Maximum recorded count is five on several occasions.

Earliest recorded eggs are 31 May 1946 at Decoigne (Cowan 1955). Earliest recorded young are 15 June 1943 at Talbot Lake (Cowan 1955).

Autumn migration lasts from August until late September. Peak migration is early September. Maximum recorded count is five on 28 September 1977 at Vermilion Lakes. Latest record is 23 September 1977 at Vermilion Lakes.

HABITAT

Most Ospreys occur along lakes and rivers in the montane; there are two nests on large lakes in the lower subalpine and upper subalpine ecoregions, and hunting Ospreys will wander to large lakes from their nest sites at lower elevations.

Ospreys nest on tall trees and, occasionally, power poles near water. Douglas-fir and white spruce are trees most commonly used. Ospreys hunt on rivers, lakes, ponds and marshes supporting fish populations.

LIFE HISTORY

Predation has been observed on suckers, unidentified fish, and, at Twintree and Amethyst Lakes, rainbow trout.

Ospreys have been observed being harassed by Bald Eagles, and have been seen chasing Bald Eagles as well. Canada geese occasionally preempt Osprey nests at Decoigne (Cowan 1955), Talbot Lake and Vermilion Lakes but since the goslings usually hatch in mid-May, there is adequate time for ospreys to use the nests after the geese have abandoned them.

GYRFALCON *Falco rusticolis* **GYRF**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: very rare visitor
Winter: not recorded

The Gyrfalcon breeds throughout the Arctic regions of the Northern Hemisphere (Godfrey 1966). The species occurs occasionally in Alberta during autumn and winter, mostly on the prairies (Salt and Salt 1976).

In Banff and Jasper the Gyrfalcon is a very rare wanderer. There are only four records on file: one near Saskatchewan River crossing on 23 May 1945, one at the Columbia Icefield in July 1938 (Cowan 1955) one at Wilcox Pass on 20 August 1957 (Hohn 1958) and one at Lake Louise on 16 August 1970.

PRAIRIE FALCON *Falco mexicanus* **PRFA**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: rare migrant
Winter: not recorded

The Prairie Falcon breeds in the Great Plains and dry inter-montane valleys of western North America south to the Mexico border (Godfrey 1966). In Alberta this species occurs locally throughout the prairies and lower foothills and "although the boundaries of the breeding range of the Prairie Falcon have changed little during this century, the number of breeding birds has declined sharply" (Salt and Salt 1976).

In Banff and Jasper the Prairie Falcon appears in late summer in the valleys of the Front Ranges (Figure 3.17, 3.18); there is only one record out of 20 since 1975 that was from the Main Ranges, one seen on 26 September 1979 at Canoe Pass at the Whirlpool River headwaters. There appears to be no records before 1975.

There is a single spring record of this species in Jasper; one was seen on 26 March 1980 near Vine Creek, Jasper (KVT).

There are only four records of this species during the breeding season, although records of unidentified large falcons may have been this species. One was observed on 27 May 1978 in the lower North Saskatchewan River valley, another on 12 June 1978 in the lower Bow River valley, another on 20 July 1979 in the upper Rocky River valley, and another on 23 July 1980 at the Jasper sanitary landfill.

Autumn migration is during August and September. Earliest record is 1 August 1979 in the lower Athabasca River valley. Maximum count is two on 9 September 1979 on the Endless Chain. Latest record is 26 September 1979 on Canoe Pass.

HABITAT

Figure 3.17. Distribution of falcon observations in Banff.

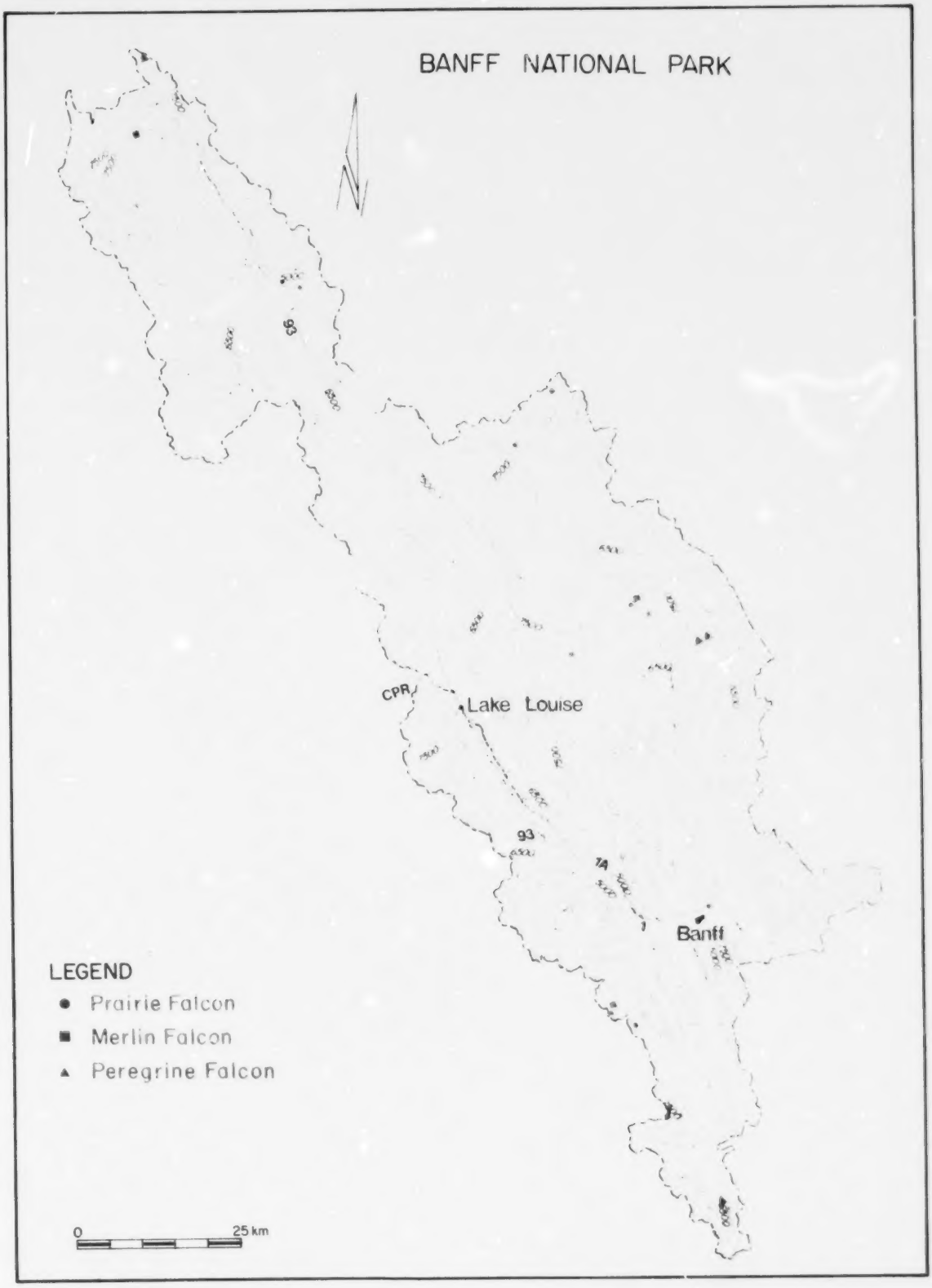


Figure 3.18. Distribution of falcon observations in Jasper.

The Prairie Falcon frequents open areas in the montane, upper subalpine, and alpine ecoregions. Migrating Prairie Falcons have been observed hunting in alpine meadows and the open, tree-island country of timberline; on steep, semi-open mountain slopes; in alluvial wetlands; and near sanitary landfills, all in valleys of the front ranges.

LIFE HISTORY

Predation attempts have been recorded in Banff and Jasper on Columbian ground squirrel, waders, gulls, and an Eastern Kingbird. There is also a record of a Prairie Falcon harassing a Common Raven.

PEREGRINE FALCON *Falco peregrinus* **PEFA**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: very rare migrant
Winter: not recorded

The Peregrine Falcon occurs on every continent of the world, most commonly in coastal areas (Godfrey 1966). Breeding Peregrine Falcons, formerly relatively common in Alberta, disappeared from the province during the 1950's (Salt and Salt 1976). Captive breeding by the Canadian Wildlife Service has resulted in local re-establishment of the species by the late 1970's but it is still uncommon in Alberta.

In Banff and Jasper (Figure 3.17, 3.18), this species has never occurred as more than an accidental migrant or non-breeding wanderer. There is an unconfirmed report that peregrines formerly nested on the Pallisades in Jasper (R. Fyfe, pers.comm.). There were six recorded observations since 1975. One was seen on 7 September 1977 (JWW) and one on 12 August 1976 (GLH) in the lower Athabasca River valley. One was seen on 26 July and again on 28 July 1979 in the Panther River valley. One was seen on 10 May 1977 near Parker's Ridge, and another on 28 June 1977 in the Spray River valley.

Clarke and Cowan (1945) cite only a single observation in Banff, but in Jasper it was considered a "... rare visitant... during autumn migration" (Cowan 1955).

HABITAT

All observations of Peregrine Falcons have been in the montane and upper subalpine ecoregions, where they were observed soaring along mountain slopes near timberline or hunting lake edges and alluvial wetlands in the larger river valleys.

MERLIN *Falco columbarius* **(b?)** **MERL**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: very rare resident
Autumn: very rare migrant
Winter: not recorded

The Merlin breeds in parts of all continents but Antarctica (Godfrey 1966). The species breeds throughout Alberta. Its numbers had declined substantially by the early 1970's (Salt and Salt 1976), but have recently increased again (R. Fyfe, Canadian Wildlife Service, pers.comm.).

In Banff and Jasper the Merlin is rarely observed; fourteen sightings were recorded between 1976 and 1980, of which ten were in the Front Ranges. Half of these observations were in August.

Spring migration is during May. Earliest record is 6 May 1976 in the lower Athabasca River valley. Maximum recorded count is two.

There are no breeding records for Banff or Jasper but repeated observations of a pair near Henry House in June 1944 (Cowan 1955) and Jasper in June 1978 indicate that this species may nest occasionally.

Autumn migration is in August and early September. Maximum recorded count is one on all occasions. Latest record is 11 September 1966 at Bryant Creek.

HABITAT

This species occurs in all ecoregions but the three records in the alpine ecoregion were during August, when Merlins are migrating. Merlins are most commonly observed in open pine forests adjacent to grassland or wetlands, on semi-open mountain slopes, and occasionally hunting at or above timberline.

LIFE HISTORY

There is only one record of predation by a Merlin in Jasper; a female was seen carrying a Brown-headed Cowbird on 25 May 1979 at Pocahontas Pond.

AMERICAN KESTREL *Falco sparverius* **(B)** **AMKE**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: fairly common resident
Autumn: uncommon migrant
Winter: not recorded

The American Kestrel breeds throughout the Western Hemisphere except in the arctic region. It nests throughout Alberta.

Of 129 records in Banff and Jasper since 1975, 108 were in the valleys of the Front Ranges and 53 were in the Athabasca River and Bow River valleys. It has been

recorded at least once in most major drainages.

Spring migration is during April and May. Peak migration is early May. Earliest record is 22 April 1979 in Jasper. Maximum recorded count is five on 29 May 1951 in the Miette River valley (Jasper warden cards).

Earliest recorded nest is 5 June 1977 in the Sunwapta valley. Earliest recorded young are 23 July 1944 at Medicine Lake (Cowan 1955).

Autumn migration is during August and September. Peak migration is late August. Maximum recorded count is 12 on 13 August 1943 at Devona (Cowan 1955). Latest record is 14 October 1978 in the lower Athabasca River valley.

HABITAT

Open forest and forest edges in the montane, lower subalpine and upper subalpine ecoregions are preferred by American Kestrels. They nest in abandoned woodpecker holes, being consequently dependent on an abundant supply of standing dead trees, and forage usually in grassy and shrubby openings. They are most frequently found at forest edges near streams and ponds (62 of 129 records), roadsides and railroad rights-of-way (24), burned areas (10), and avalanche slopes (4).

Open spruce forest on alluvial sites is the most favoured forested habitat (16), followed by pine forest (10) and poplar forest (10). Mature spruce forest is rarely used by American Kestrels (8) except where it adjoins more open habitats.

Only 24 American Kestrels were recorded on 1736 call-count transects. The highest densities are on alluvial habitats (DI=1.12, n=12) and in shrub meadows (DI=1.21, n=8) and open spruce forest (DI=1.28, n=4).

LIFE HISTORY

Successful predation has been observed on an American Robin and a vole. American Kestrels have been observed being harassed by American Robins once and Barn Swallows twice, and harassing a Golden Eagle once.

BLUE GROUSE *Dendragopus obscurus* **(B)** **BLGR**

STATUS AND DISTRIBUTION

Spring: uncommon resident
Summer: uncommon resident
Autumn: very rare resident
Winter: very rare resident

The Blue Grouse breeds throughout the mountainous western part of North America from the eastern foothills of the Rocky Mountains west to the Pacific Coast, and also in the Black Hills of South Dakota (Godfrey 1966). In Alberta it occurs only in the mountains and their foothills (Salt and Salt 1976).

In Banff and Jasper the Blue Grouse is present all year round but is readily located only during late May and June when the males are vocal. Forty of 51 records of this species and 11 of 13 records of broods are from the drier, more open valleys of the Front Ranges (Figure 3.19, 3.20). Formerly burned areas along the Cascade fire road, Clearwater River, Isaac Creek and Cairn River valleys are among the places where Blue Grouse are most commonly observed. Hooting males can be heard along the Celestine

Figure 3.19. Distribution of grouse observations in Banff.

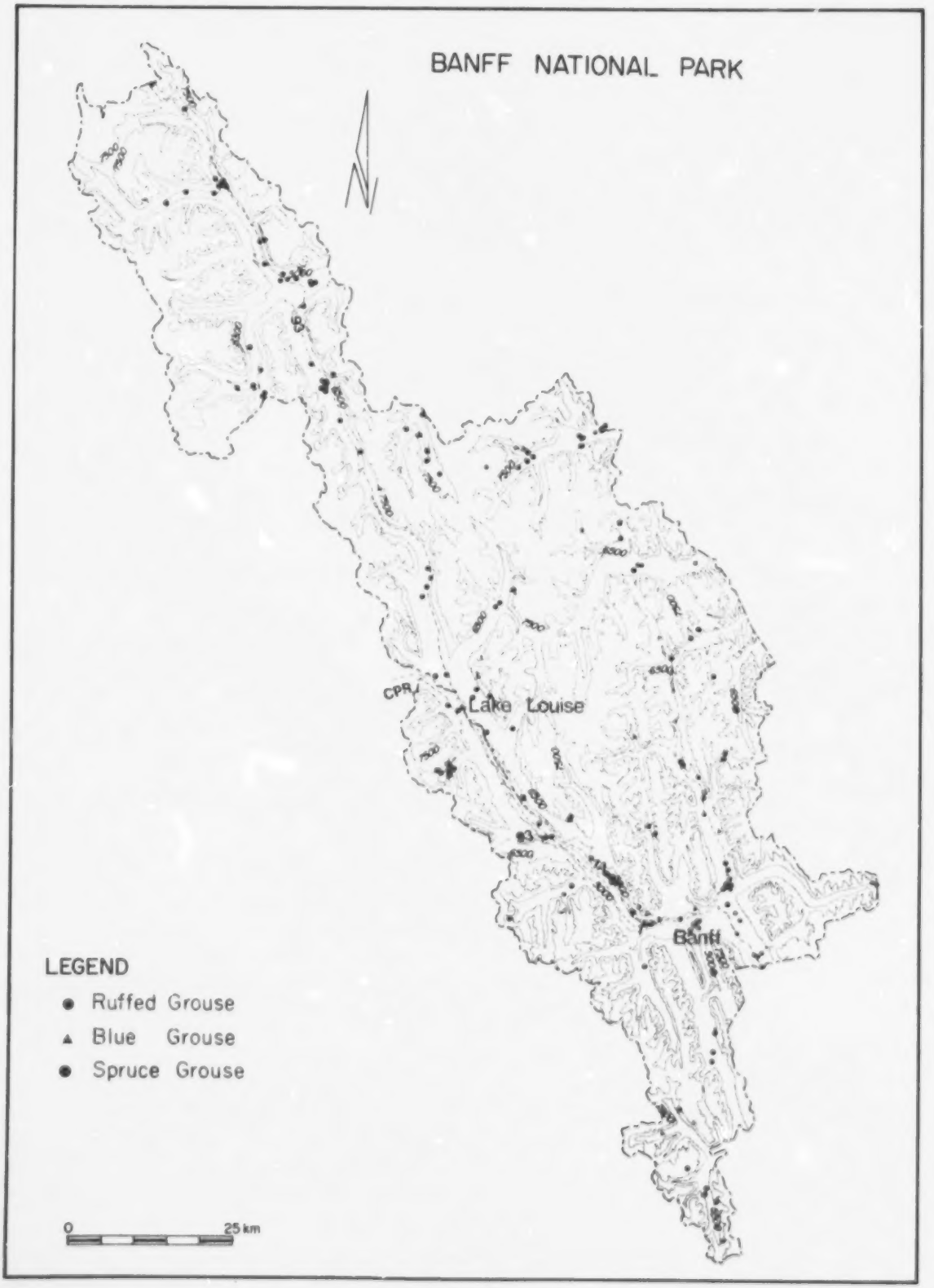
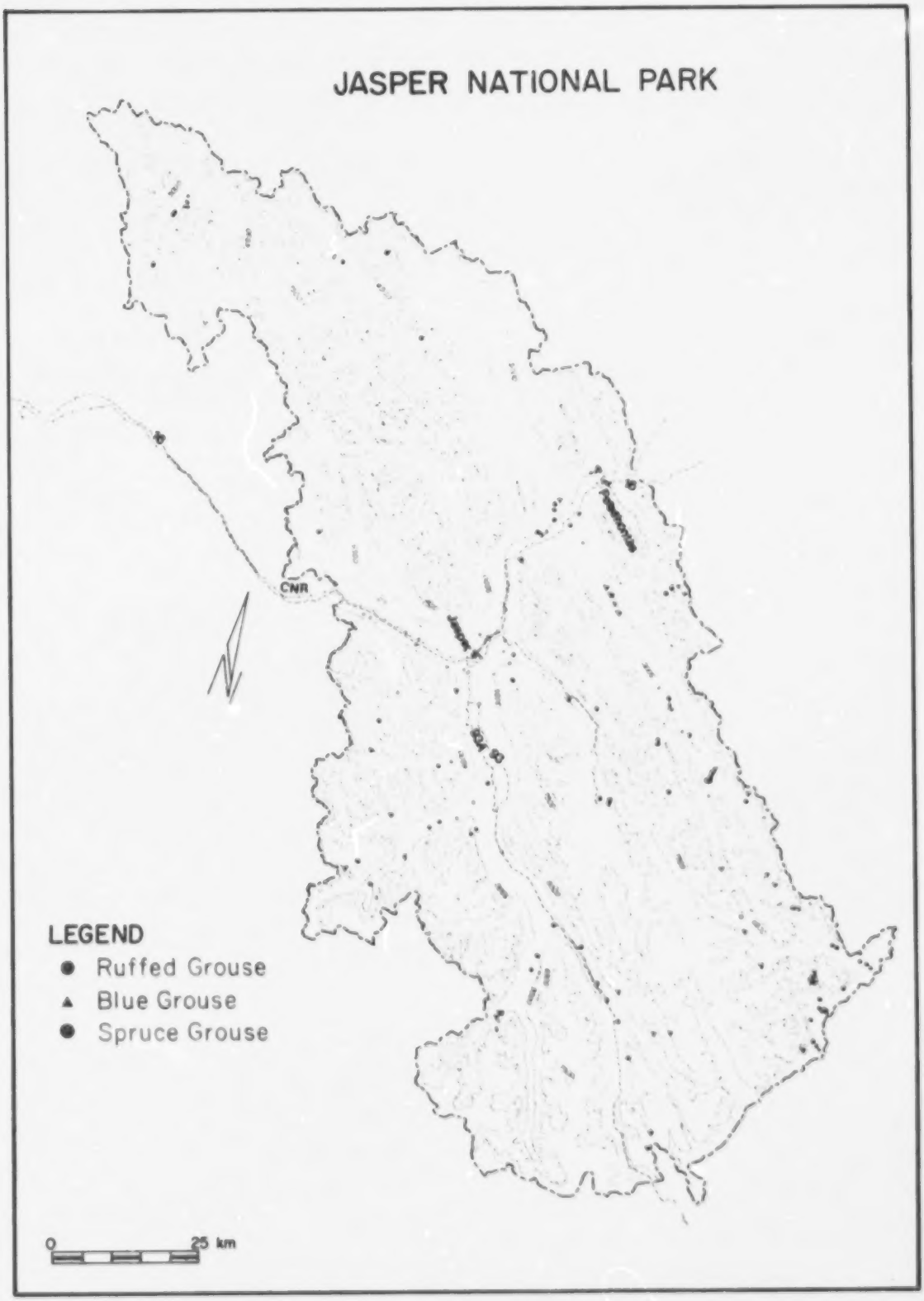


Figure 3.20. Distribution of grouse observations in Jasper.



fire road and highway 1A near Muleshoe.

Young have been recorded as early as 29 June 1977 in the upper Spray River and as late as 9 September 1967 at Flints Park, Banff.

HABITAT

Of 51 records of Blue Grouse in Banff and Jasper during this inventory, 23 were in open spruce forest, 11 in shrub meadows, 7 on avalanche slopes and 7 on the edges of pine forests. This species occurs most frequently on dry slopes and old burns in the montane, lower subalpine and upper subalpine ecoregions in summer. There are no winter records of Blue Grouse in Banff and Jasper although they are probably present, spending most of their time in trees in upper subalpine forests.

LIFE HISTORY

Blue grouse are most readily located during May when territorial males are vocalizing. There are two calls, one is a series of almost inaudible, very low-pitched hoots. The other is a single, low-pitched hoot audible at a considerable distance, which is uttered at the end of a brief run towards the watching hen. Most of this vocalization and displaying takes place in open coniferous forest with an open understory, usually on or adjacent to a steep slope. Such areas that are readily accessible by road include the Celestine Fire Road and Highway 1A east of Johnston Canyon.

SPRUCE GROUSE *Canachites canadensis* **(B)** **SPGR**

STATUS AND DISTRIBUTION

Spring: uncommon resident
Summer: uncommon resident
Autumn: uncommon resident
Winter: uncommon resident

The Spruce Grouse occurs throughout the coniferous forests of northern and western North America (Godfrey 1966). In Alberta it occurs in all but the aspen parkland and grassland regions (Salt and Salt 1976).

In Banff and Jasper the Spruce Grouse is relatively ubiquitous (Figure 3.19, 3.20), being found in all major valleys having mature spruce, pine or mixed forest. Populations appear to fluctuate over a period of years such that the species may vary from uncommon to fairly common.

Nests and broods have been recorded on numerous occasions. The earliest recorded nest with eggs is 31 May 1979 in the lower Athabasca River valley. Earliest recorded brood is 3 July 1977 in the North Saskatchewan River valley and the latest record of a female with readily identifiable young is 7 September 1976 and 1978 (RGK, LMC).

HABITAT

Spruce Grouse frequent coniferous forests in the montane, lower subalpine and upper subalpine ecoregions. Of 182 observations of this species, 142 were in closed coniferous forest and of these, 82 were in closed lodgepole pine or lodgepole pine-spruce forest.

On 1736 call-count transects 26 Spruce Grouse were recorded with the highest density index being 4.42 in spruce bogs (n=3), and density indices of 2.55 in spruce/fir forests (n=13) and 1.36 in lodgepole pine and lodgepole pine-spruce forest (n=9). Spruce Grouse are most abundant on alluvial fans and floodplains; density indices of 4.85 (n=7) and 4.19 (n=6) were recorded on these habitat types during call-count transects. There are very few winter observations of Spruce Grouse since at this season they spend most of their time quietly feeding in the branches of spruce trees.

LIFE HISTORY

Although male Spruce Grouse vocalize during the breeding season (May and early June) the calls are at such a low pitch that they are not audible to human ears. Nonetheless, this is the season during which the species is most detectable because males often display on hiking trails and fire roads in suitable habitat. The males are highly approachable and will display to humans and even to vehicles at this season.

At all seasons the Spruce Grouse is readily approached by humans and the species apparently does not identify the upright human figure with danger, although dogs are avoided by flying up into the branches of a conifer.

Evidence of predation on Spruce Grouse by Goshawk and wolverine has been observed in Jasper.

RUFFED GROUSE *Bonasa umbellus* **(B)** **RUGR**

STATUS AND DISTRIBUTION

Spring: fairly common resident
Summer: fairly common resident
Autumn: fairly common resident
Winter: very rare resident

The Ruffed Grouse occurs throughout the forested regions of North America north of California, South Dakota and Georgia (Godfrey 1966). The species breeds throughout Alberta except in the prairies (Salt and Salt 1976).

In Banff and Jasper Ruffed Grouse populations fluctuate over a number of years such that the species may vary from uncommon to fairly common (Figure 3.21). Of 114 records of Ruffed Grouse, all but 19 are from the valley bottoms of the Front Ranges; there are 53 records from the Athabasca River and Bow River valleys (Figure 3.19, 3.20).

Ten nests were found since 1975. Earliest recorded nest with eggs is 6 June 1979 in the lower Cascade River valley. Earliest recorded young are 10 June 1978 in the Athabasca River valley.

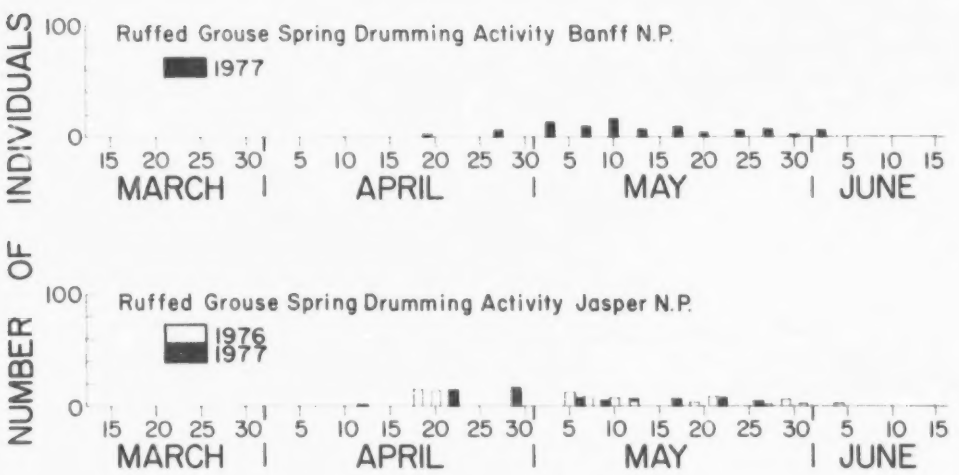
There are only seven winter records of Ruffed Grousesince 1975, but this more likely indicates that they feed quietly in trees than that they leave the park in winter.

HABITAT

Ruffed Grouse frequent deciduous and mixed forest, and white spruce forest to a lesser degree, in the montane and lower subalpine ecoregions, rarely occurring in the upper subalpine ecoregion.

Of 114 records of Ruffed Grouse in Banff and Jasper, 74 are from the montane and 38 from the lower subalpine ecoregion. Pine forest (37) and deciduous forest (33)

Figure 3.21. Ruffed Grouse spring drumming activity, based on numbers heard on spring migration surveys.



are preferred. On 1736 call count transects, 37 Ruffed Grouse were recorded with highest density indices of 2.12 (n=9) in deciduous forest and 1.82 (n=8) in montane spruce forest. In terms of ecosites, the highest density indices are 2.16 (n=7) on montane floodplains, and 2.05 (n=22) on alluvial fans. Montane ecosites in which Ruffed Grouse occur have a higher average density index (2.08, n=22) than lower subalpine ecosites (0.83, n=15) in which they were recorded.

WILLOW PTARMIGAN *Lagopus lagopus* **(B)** **WIPT**

STATUS AND DISTRIBUTION

Spring: uncommon resident
Summer: uncommon resident
Autumn: uncommon resident
Winter: uncommon resident

The Willow Ptarmigan breeds in arctic and alpine regions of the northern parts of North America, Europe and Asia (Godfrey 1966). In Alberta it breeds in the northern Rockies and flocks from the Northwest Territories winter in the northern part of the province (Salt and Salt 1976).

In Banff there are no Willow Ptarmigan. In Jasper the species is a year round resident of most parts of the park and has been recorded breeding as far south as the upper Rocky River and Poboktan Pass. Wintering Willow Ptarmigans have been recorded in Sunwapta Pass and there are 2 autumn records from south of the Brazeau River in the Job Creek drainage.

There are no nest records but young broods have been recorded six times since 1975. Earliest recorded young are 22 June 1972 at Moose Pass (Jasper warden cards).

HABITAT

Willow Ptarmigan frequent open forests and shrub meadows in the upper subalpine ecoregion. Of 27 records, only four were in the alpine ecoregion. Open spruce/fir timberline forest accounted for 12 of these observations and willow shrub meadows for another six. In summer Willow Ptarmigans frequent the upper subalpine ecoregion to a greater extent than do White-tailed Ptarmigan, but both species occur in the same upper subalpine stream meadows and open forests in winter.

Only seven Willow Ptarmigan were recorded on 1736 call-count transects.

WHITE-TAILED PTARMIGAN *Lagopus leucurus* **(B)** **WHPT**

STATUS AND DISTRIBUTION

Spring: fairly common resident
Summer: fairly common resident
Autumn: fairly common resident
Winter: fairly common resident

The White-tailed Ptarmigan occurs in alpine regions of the mountains of western North America from Alaska south to Mexico (Godfrey 1966). In Alberta it occurs in the mountains and rarely winters in the lower foothills (Salt and Salt 1976).

In Banff and Jasper this species is widespread, occurring in suitable habitat throughout both parks.

Earliest recorded nest is 7 June 1977 at Wilcox Pass, and earliest recorded young are 28 June 1980 in the Snake Indian River valley.

HABITAT

This species frequents open rocky areas and alpine meadows near streams in summer, and upper subalpine willow meadows and open forests in winter.

Of 151 summer observations of White-tailed Ptarmigan 60 were in dry alpine meadow areas, 60 in moist to wet alpine meadows, 20 in open timberline forest, and 7 in willow shrub meadows. Of 45 broods recorded, 18 were near streams in moist meadows, 15 were in dry meadows, and none were in shrub meadows.

In winter flocks of White-tailed Ptarmigan forage at somewhat lower elevations and in more sheltered areas: of 35 winter observations 13 were in willow shrub meadows, 9 in open forest, 5 in closed forest, and only 8 in open meadows at or above treeline. All observations of winter feeding have been on willows. White-tailed Ptarmigan and Willow Ptarmigan frequent different habitats in breeding season, the latter preferring lusher vegetation with scattered clumps of trees, but their winter habitat requirements are very similar and both species are seen close to each other (but not in mixed flocks) at this season.

SHARP-TAILED GROUSE *Pedioecetes phasianellus* **SHGR**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare visitor
Winter: very rare visitor

The Sharp-tailed Grouse breeds throughout much of the northwestern part of North America from Alaska and the Yukon east to Quebec and south to Michigan and Colorado (Godfrey 1966). It occurs throughout Alberta but is rare in the mountains (Salt and Salt 1976).

In Banff and Jasper this species is a very rare winter resident. There are no records more recent than November 1961 at Willow Creek and it was evidently more

common, especially in the Willow Creek area, before the 1940's (Cowan 1955). The only record for Banff is from the winter of 1913-14 (Clarke and Cowan 1945).

During population erruptions of this species in other parts of its range, extensive migrations may occasionally occur (Godfrey 1966). At such times Sharp-tailed Grouse may be expected to appear in Banff and Jasper. Such was evidently the case in the autumn of 1941 when large numbers appeared in the lower Athabasca River valley and moved through Jasper to Sunwapta Pass and Fortress Lake (Cowan 1955). There is a breeding record from Yoho National Park (Van Tighem 1978).

RING-NECKED PHEASANT *Phasianus colchicus* **RIPH**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: very rare visitor
Winter: very rare visitor

The Ring-necked Pheasant is an Eastern Asian species which has been introduced to agricultural areas of Europe and North America (Godfrey 1966). In Alberta it is commonest in the irrigated areas of the southern prairies but also occurs locally in the aspen parkland region and the Peace River district (Salt and Salt 1976).

There are only three records of Ring-necked Pheasants in Banff and none in Jasper; one was observed on 21 June 1973 at Mt. Norquay (Gordon 1975), one was seen at the Indian Days grounds in October 1967 (G. Trottier pers. comm.)and one was found dead beneath a window in Banff townsite in January 1983. These are both unusual records since pheasants are rarely observed west of Calgary and are not noted for long distance travel.

GRAY PARTRIDGE *Perdix perdix* **GRPA**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: not recorded
Autumn: very rare visitor
Winter: very rare visitor

The Gray Partridge is a Eurasian species which has been introduced to agricultural areas of Canada and the United States. In Alberta it occurs throughout the southern and central part of the province and the Peace River district, but is most common in the prairies.

In Banff and Jasper this species is a very rare winter straggler. There are old records from Banff and Johnston Canyon (Clarke and Cowan 1945) and some Gray Partridges appeared in Jasper during the 1941 influx of Sharp-tailed Grouse (Cowan 1955). The only recent record is of a single bird which fed on spilled grain along the CNR railroad at Jasper townsite during April of 1980, and was killed by an automobile on highway 16 on 30 April 1980.

SANDHILL CRANE *Grus canadensis* **SACR**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare visitor
Winter: not recorded

The Sandhill Crane breeds from northeastern Siberia, Alaska and Arctic Canada south locally to Florida and Cuba. In Alberta it breeds throughout the northern third of the province and, locally, in the lower foothills as far south as Rocky Mountain House.

Sandhill Cranes have not been observed in Banff; in Jasper they are very rare migrants. Their historical status (five records in Jasper in August and September) is somewhat uncertain due to the tendency of some observers to call Great Blue Herons "cranes". On 21, 22 and 23 September 1945, a large scale migration involving over 500 birds was observed in the lower Athabasca River valley (Cowan 1955). This occurrence was tentatively attributed to exceptionally bad weather causing the cranes to alter their normal migration route.

VIRGINIA RAIL *Rallus limicola* **VIRA**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: not recorded
Autumn: not recorded
Winter: not recorded

The Virginia Rail breeds locally from southern boreal Canada south to the southern tip of South America. In Alberta it breeds in the eastern part of the province from Fort Chipewyan south to Brooks.

There is only a single record of this species from Banff: an individual was found dead near Bow Summit on 1 May 1968 (Cunningham 1969).

SORA *Porzana carolina* **(b?)** **SORA**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: uncommon visitor
Winter: not recorded

The Sora breeds from the low arctic of North America south to Baja California and the southern United States (Godfrey 1966). It occurs in suitable habitat throughout Alberta (Salt and Salt 1976).

In Banff and Jasper the Sora occurs locally in most major drainages being most frequently observed at Vermilion Lakes and Talbot Lake. Of 50 records of Soras 31 are from the Athabasca River and Bow River valleys.

Spring migration is in May, peaking in late May. Earliest record is 6 May 1978. Maximum recorded count is 21 on 28 May 1978 at Vermilion Lakes.

No nests have been recorded but the species is present throughout the breeding season at Vermilion Lakes, Cave and Basin swamp, near Muleshoe in the middle Bow River valley, Waterfowl Lakes, Graveyard Flats, Beauty Creek flats, Miette River backswamps, lower Athabasca River valley, and Snake Indian Lakes. The latest record is one on 28 August 1952 in Jasper.

HABITAT

Soras frequent wetlands in the montane, lower subalpine and rarely upper subalpine ecoregions, wherever there are extensive beds of sedges, rushes or flooded willows. Of 50 observations of Soras, 18 were associated with willow shrubbery and 17 with emergent sedge vegetation.

YELLOW RAIL *Coturnicops noveboracensis* **YERA**

STATUS AND DISTRIBUTION

The Yellow Rail breeds from southern Canada east of the Rocky Mountains locally south to the central United States, as well as eastern California and Mexico (Godfrey 1966). In Alberta it breeds in the eastern half of the province from Lake Athabasca south locally to Ribstone Creek (Salt and Salt 1976).

There is only one record of Yellow Rails in Jasper, two specimens were collected near Jasper early in the century (Preble 1908).

AMERICAN COOT *Fulica americana* **AMCO**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: uncommon visitor
Autumn: common migrant
Winter: very rare resident

The American Coot breeds from boreal Canada south to Central America and the northern Andes, as well as on the Hawaiian Islands (Godfrey 1966). It breeds throughout Alberta except in the mountains (Salt and Salt 1976).

In Banff and Jasper the American Coot is most regularly seen on Vermilion Lakes and Talbot Lake and other wetlands in the Bow River and Athabasca River valleys. Of 38 observations of this species 34 were in these two valleys.

Spring migration is during April and May. Peak migration is late April and early May. Earliest record is 29 March 1978 at Vermilion Lakes. Maximum recorded count is 169 on 9 May 1979 in the lower Athabasca River valley. Latest record is 2 June 1977 at Vermilion Lakes.

No nests or broods of young have been recorded in Banff and Jasper. Autumn migration lasts from mid-August until freeze-up in early November. Peak migration is in late September. Earliest record is 12 August 1977 at Vermilion Lakes. Maximum recorded count is 271 on 29 October 1971 in the lower Athabasca River valley. Latest record is 8 November 1978 at Talbot Lake.

American Coots do not usually winter in Banff and Jasper. There is a single record from 8 February 1954 at Vermilion Lakes (Banfield 1954a).

HABITAT

American Coots frequent wetlands and sedgy lake edges in the montane (34 of 38 records) and lower subalpine (4) ecoregions. They prefer shallow water, usually near emergent vegetation or flooded willows.

SEMIPALMATED PLOVER *Charadrius semipalmatus* **SEPL**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: uncommon migrant
Winter: not recorded

The Semipalmated Plover breeds in arctic North America, the Queen Charlotte Islands and the Atlantic sea coast, and migrates across most of North America. In Alberta it is a regular spring and autumn migrant east of the mountains.

There is one record of this species in Banff: one was seen at Merlin Lake on 18 August 1978 (GLH). In Jasper it is a very rare and irregular autumn migrant. There are only 5 records, 3 from Jasper Lake. The earliest record is 13 August 1979 at Jasper Lake. Maximum recorded count is 7 on 14 August 1977 on the lower Athabasca River. Latest record is 25 August 1979 at Jasper Lake.

HABITAT

All but one observation of Semipalmated Plover have been on sandy beaches and mudflats in the montane ecoregion; there is one record from an upper subalpine lakeshore.

KILLDEER *Charadrius vociferus* **(B)** **KILL**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: fairly common migrant
Winter: rare resident

The Killdeer breeds from the boreal regions of Canada south to the West Indies and Peru (Godfrey 1966). It breeds throughout Alberta (Salt and Salt 1976).

In Banff and Jasper this species is sparsely but widely distributed, occurring in all major drainages. It is most common along the larger rivers such as the Athabasca River (17 of 74 records), Bow River (29), Clearwater River (4), Howse River (4), North Saskatchewan River (4), and Smoky River (3).

Spring migration is during March, April, and early May. Peak migration is late April. Earliest record is 8 March 1975 at the Cave and Basin Swamp (McIvor and McIvor 1980). Maximum recorded count is seven on 2 May 1978.

Earliest recorded nest is 15 May 1952 at Moberley Flats (Jasper warden cards). Earliest recorded young are 18 July 1939 on the North Saskatchewan River (Clarke and Cowan 1945).

Autumn migration is during August and early September. Peak migration is late August. Maximum recorded count is 12 on 25 August 1979 in the lower Athabasca River valley. Latest record is 17 September 1978 in the lower Bow River valley.

Killdeers rarely winter in Banff and Jasper. Individuals were recorded on the 1961, 1976, 1977 and 1979 Banff Christmas bird counts and at the Cave and Basin swamp on 16 January 1977 and 1 and 2 January 1978 (McIvor and McIvor 1980).

HABITAT

Open areas near water in the montane (27 of 74), lower subalpine (42) and rarely upper subalpine (5) ecoregions are frequented by Killdeers. Killdeers frequent gravelly stream and river channels (22), sedge and willow meadows with ponds or streams (26), lake shores (17), and disturbed areas such as sewage lagoons, landfills and borrow pits.

GOLDEN PLOVER *Pluvialis dominica* **GOPL**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: not recorded
Autumn: very rare migrant
Winter: not recorded

The Golden Plover breeds in northern Siberia and arctic regions of Alaska and Canada. It is a regular spring and autumn migrant throughout Alberta east of the mountains.

In Banff and Jasper this species is a rare and irregular migrant that has been recorded only in the lower Athabasca River and lower Bow River valleys.

There are two spring records. Four were seen on 13 May 1970 and in May 1972 at Vermilion Lakes (Gordon 1975).

There are four autumn records, all from the lower Athabasca River valley. Individuals were observed at Mile 18 Pond on 24 and 25 August 1979 (DJH); 6 were observed on 22 September 1945, also at Mile 18 pond (Cowan 1955); and one was seen on 5 October 1950 by A.W.F. Banfield (Jasper warden cards).

HABITAT

All observations of Golden Plovers in Banff and Jasper have been on exposed mudflats with sedges along lake shores in the montane ecoregion.

BLACK-BELLIED PLOVER *Pluvialis squatarola* **BLPL**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare visitor
Winter: not recorded

The Black-Bellied Plover breeds in the high and mid-arctic of Canada and Alaska west to the Kanin Peninsula of Russia (Godfrey 1966). It is a regular spring and autumn migrant throughout Alberta east of the mountains (Salt and Salt 1976).

There are two records of this species in Banff and two in Jasper. One was observed on 10 September 1976 at Two Jack Lake and 2 on 18 September 1978 at the Banff recreation grounds (McIvor and McIvor 1980). One was collected by Byron Harmon from a flock at Maligne Lake on 15 September 1911 (Cowan 1955), and three were seen on 17 September 1977 at Mile 18 Pond (DJK).

HABITAT

Black-Bellied Plovers frequent mudflats and shorelines on migration (Salt and Salt 1976). The Jasper records are from a muddy backwater on the lower Athabasca River in the montane ecoregion, and an upper subalpine lakeshore. Both Banff records are from the montane ecoregion.

COMMON SNIPE *Capella gallinago* **(B)** **COSN**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: fairly common resident
Autumn: uncommon migrant
Winter: very rare resident

The Common Snipe breeds throughout most of the low arctic, boreal and cold temperate regions of the Northern Hemisphere (Godfrey 1966). It breeds throughout Alberta (Salt and Salt 1976). Common Snipes occur in suitable habitat throughout most of the major valleys of the parks, but are commonest in the wetlands and backwaters of the Athabasca

River and Bow River valleys (77 of 115 records since 1975).

Spring migration is in late April and May. Peak migration is in early May. Earliest record is 7 April 1978 at Vermilion Lakes. Maximum recorded count is 14 on 9 May.

There are four breeding records since 1975. The earliest recorded nest is 1 June 1977 in the Sunwapta River valley. Earliest recorded young are 9 July 1977 in the upper Bow River valley.

Autumn migration is in August and September. Maximum recorded count is nine on 10 August 1979 at Pocahontas Pond. Latest record is 17 October 1977 at Vermilion Lakes. Common Snipes occasionally winter in Banff, especially in the vicinity of the Cave and Basin swamp and Athracite. From one to five were recorded annually on Banff Christmas bird counts from 1975 to 1979. One was recorded on four occasions between 3 January and 21 February 1976 at the Cave and Basin (McIvor and McIvor 1980).

HABITAT

Common Snipes frequent marshy areas in the montane and lower subalpine ecoregions. Only 4 of 115 records since 1975 were in the upper subalpine ecoregion. Sedge and willow wetlands on stream floodplains are the most important habitat. On 1736 call-count transects, 61 Common Snipes were recorded; 35 of these were on montane floodplains and 11 were on lower subalpine floodplains.

ESKIMO CURLEW *Numenius borealis*

The eskimo curlew was an arctic species which is know to have bred in the Mackenzie district and, possibly, northern Alaska (Godfrey 1966). It was probably a migrant through Alberta (Salt and Salt 1976).

There is only one possible record of this species in Jasper National Park; "there is a specimen described by Richardson... which presumably was part of Drummond's collection from the Jasper area" (Cowan 1955) taken in 1826.

UPLAND SANDPIPER *Bartramia longicauda* **(b?)** **UPSA**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: very rare migrant
Winter: not recorded

The Upland Sandpiper breeds from southern Alaska and Yukon south through the temperate regions of North America to the southern U.S.A. (Godfrey 1966). It breeds in suitable habitat throughout Alberta except the high foothills and mountains (Salt and Salt 1976).

In Banff and Jasper the Upland Sandpiper is very rare; there are only three recorded occurrences. A pair which behaved as if they were on a breeding territory was observed at the head of the Siffleur River on 15 July 1943 (Clarke and Cowan 1945). There are two autumn records: one was seen in the grassland adjacent to the Banff Indian Days Grounds in 20 August 1970 (MED), and one was seen at Jasper townsite on 25 August 1979 (JNP naturalist files).

HABITAT

"Open grassy uplands... prairies; also (in Yukon) sandy, sparsely vegetated flats and bogs up to timberline" (Godfrey 1966). The Banff and Jasper records are from developed townsites, from a shrubby upper subalpine alluvial meadow, and from a montane grassland on an alluvial fan.

SPOTTED SANDPIPER *Actitis macularia* **(B)** **SPSA**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: fairly common resident
Autumn: fairly common migrant
Winter: not recorded

The Spotted Sandpiper breeds from the arctic south to the southern United States (Godfrey 1966). In Alberta it occurs throughout the province (Salt and Salt 1976).

In Banff and Jasper this species occurs in all parts of both parks.

Spring migration is during May and early June. Peak migration is late May. Earliest record is 6 May 1980 near Lake Louise. Maximum recorded count is 20 on 28 May 1978 in Banff.

Earliest recorded nest is 24 May 1975 in the Bow River valley. Earliest recorded brood is 24 July 1975 in the Bow River valley.

Autumn migration is during August and early September. Maximum recorded count is six on 15 August 1979 along the lower Rocky River. Latest record is 13 September 1977 in the Athabasca River valley.

HABITAT

Spotted sandpipers frequent gravelly beaches and river shores, mudflats, wetlands, glacial outwash plains, and the edges of lakes and ponds. Highest density indices recorded on bird transects were 27.81 (n=9) in upper subalpine alluvial meadows with shrubby vegetation, 19.17 (n=38) in lower subalpine alluvial meadows with shrubby vegetation, 19.78 (n=4) in upper subalpine till deposits with shrubby vegetation, and 12.36 (n=3) in upper subalpine alluvial meadows with herbaceous vegetation.

SOLITARY SANDPIPER *Tringa solitaria* **(B)** **SOSA**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

The Solitary Sandpiper breeds from central and southern Alaska across the boreal regions of Canada to Labrador (Godfrey 1966). In Alberta it breeds throughout the northern half of the province and farther south along the foothills (Salt and Salt 1976).

In Banff and Jasper this species occurs sparsely in suitable habitat in all major drainages.

Spring migration is during May. Earliest record is 3 May 1978 in the lower Bow River valley. Maximum recorded count is four on 9 May 1977 in the lower Bow River valley.

Earliest recorded nest is 7 June 1945 at Willow Creek (Cowan 1955). Earliest recorded young are 11 July 1896 in the lower Athabasca River valley (Cowan 1955). There are no nest records from 1975 to 1980 but 10 observatons in June of pairs some agitated and displaying indicates that Solitary Sandpiper stills breeds in the two parks.

Autumn migration is during August. Maximum recorded count is fifteen on 11 August 1977 at Baker Creek. Latest record is 17 September 1977 in the lower Athabasca River valley.

HABITAT

Solitary Sandpipers frequent wet shrub meadows, sedgy wetlands with scattered trees, and alluvial wetlands. On 1736 call-count transects, 17 Solitary Sandpipers were recorded. Highest density indices were recorded in shrubby alluvial meadows in the upper subalpine (5.88, n=2) and lower subalpine (2.88, n=6) ecoregions.

GREATER YELLOWLEGS *Tringa melanoleucus* **(B)** **GRYE**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: uncommon resident
Autumn: fairly common migrant
Winter: not recorded

The Greater Yellowlegs breeds throughout the boreal regions of Canada (Godfrey 1966). It breeds in the northern half of Alberta as far south, in the foothills, as Rocky Mountain House and Sundre (Salt and Salt 1976).

In Banff and Jasper this species migrates throughout the major valleys of the park but has been recorded during the breeding season (June and July) only in the Athabasca River (12 of 23 records), Bow River (7), Brazeau River (3), and Southesk River (1) valleys.

Spring migration is during late April and May. Peak migration is in early May. Earliest record is 12 April 1977 in the lower Athabasca River valley. Maximum recorded count is nine on 6 May 1976 in the lower Athabasca River valley.

There is only one recorded nest, in "May 1946" at Leach Lake in Jasper (Cowan 1955). Agitated adults were observed on 2 June 1979 at Isaac Creek (KVT), 10 June 1980 at Soggy Dog Slough (GLH), and 19 June 1978 at Patricia Lake (D.B.Donald).

Autumn migration is during August. Peak migration is mid August. Maximum recorded count is 40 on 11 August 1979 in the lower Athabasca River valley. Latest record is 12 September 1977 in the lower Athabasca River valley.

HABITAT

Greater Yellowlegs frequent alluvial wetlands, beaverponds and bogs in the montane and lower subalpine ecoregions during the breeding season. On 1736 transects 17 Greater Yellowlegss were recorded. Highest density indices were 3.92 (n=9) in montane wetlands with sedge and willow meadows, 1.96 (n=1) in montane wetlands with white spruce forest, and 0.96 (n=4) in lower subalpine alluvial meadows with shrubby vegetation.

LESSER YELLOWLEGS *Tringa flavipes* **LEYE**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: not recorded
Autumn: fairly common migrant
Winter: not recorded

The Lesser Yellowlegs breeds throughout northwestern North America east to James Bay and south to the aspen parkland region (Godfrey 1966). In Alberta it breeds throughout the northern half of the province, south in the foothills to near Turner Valley (Salt and Salt 1976).

In Banff and Jasper this species migrates through the major valleys of the Front Ranges; there is one record each from the Mistaya River, middle Cascade River and Baker Creek valleys, three from the Bow River, and eight from the Athabasca River valleys.

Spring migration is during May. There are very few spring records of this species in Banff or Jasper. Earliest record is 26 April 1970 at the Rocky River (Loewen 1970).

Autumn migration is during August and early September. Peak migration is during August. Maximum recorded count is 44 on 23 August 1978 in the lower Athabasca River valley. Latest record is 21 September 1978 in the lower Athabasca River valley.

HABITAT

Lesser Yellowlegs frequent sedge meadows along lakeshores, ponds and mudflats in the montane and lower subalpine ecoregions.

WANDERING TATTLER *Heteroscelus incanus* **WATA**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Wandering Tattler breeds in Siberia, Alaska, Yukon and northern British Columbia (Godfrey 1966). In Alberta there have only been five recorded observations of this species (Salt and Salt 1976).

The only record of a wandering tattler in Banff or Jasper is of an individual seen at Patricia Lake on 2 July 1961 (Salt and Salt 1976).

HABITAT

"In migration, usually outer rocky sea-coasts and islands. In breeding season, mountain streams and meadows" (Godfrey 1966). The Jasper record was along the edge of a montane lake.

RUDDY TURNSTONE *Arenaria interpres* **RUTU**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare visitor
Winter: not recorded

The Ruddy Turnstone breeds in the high arctic regions of the Northern Hemisphere (Godfrey 1966). It is a spring and autumn migrant through eastern Alberta, being commoner in spring (Salt and Salt 1976).

There is only a single record of this species in Banff or Jasper; an individual was seen at Bow Lake on 14 August 1979 (Holroyd 1981).

HABITAT

"Rocky shores, pebbly and sandy beaches... " (Godfrey 1966). The Banff record was along the cobbly shore of an upper subalpine lake.

SANDERLING *Calidris alba* **SAND**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare migrant
Winter: not recorded

The Sanderling breeds in arctic regions of the Northern Hemisphere (Godfrey 1966). It is a common spring and autumn migrant throughout most of Alberta except the mountains (Salt and Salt 1976).

In Banff and Jasper there are only three records of this species. One was seen at Jasper Lake on 19 September 1978 and one was reported by a birder (Tim Rose) to the Jasper naturalists, seen at Wabasso Lake between 10 and 13 August 1980 and three were photographed above Helen Lake in September 1975 (GLH)>.

HABITAT

Sanderlings frequent "... sand beaches [and] sometimes... mud flats and other muddy places... " (Godfrey 1966). Both Jasper records are from lakeshores in the montane ecoregion.

SEMIPALMATED SANDPIPER *Calidris pusilla* **SESA**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: not recorded
Autumn: fairly common migrant
Winter: not recorded

The Semipalmated Sandpiper breeds throughout much of the low arctic (Godfrey 1966). It is a fairly common spring and autumn migrant throughout most of Alberta but is less common in the mountains (Salt and Salt 1976).

In Jasper this species migrates regularly in the lower Athabasca River valley where it has been recorded 15 times out of 19 records since 1975, most observations being at Jasper Lake, Pocahontas Ponds and Mile 18 Pond. It has been recorded four times in Banff: Spreadborough collected one at Banff in May 1891 (Clarke and Cowan 1945), 1 was observed at Vermilion Lakes on 15 May 1975 (Gordon 1975), 2 were observed on 2 September 1979 at Wigmore Lake (McIvor and McIvor 1980), and 2 were seen on 13 October 1980 at Wigmore Lake (GLH).

There are only three spring records of Semipalmated Plovers. Two are listed above, and on 11 May 1976, two were seen at Talbot Lake (DJK).

Autumn migration is during August and early September. Earliest record is 27 July 1979 at Lake Annette. Maximum recorded count is 29 on 13 August 1979. Latest record is 17 September 1977 at Pocahontas Pond although there is an exceptional record for 13 October (above).

HABITAT

Semipalmated Sandpipers frequent mudflats, beaches and sedgy edges of lakes and ponds in the montane (15), lower subalpine (2) and upper subalpine (3) ecoregions.

WESTERN SANDPIPER *Calidris mauri* **WESA**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare migrant
Winter: not recorded

The Western Sandpiper breeds only in Alaska (Salt and Salt 1976). In Alberta its status is uncertain but it is probably a regular migrant in the western part of the province.

There is only a single record of a Western Sandpiper in Jasper: one was seen on 22 August 1979 at Jasper Lake (DJH).

HABITAT

Sand beaches, mud flats, open edges of pools, ponds, lakes, rivers and shores... (Godfrey 1966). The Jasper record was on an extensive sandy beach in the montane ecoregion.

LEAST SANDPIPER *Calidris minutilla* **LESA**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: very rare visitor
Autumn: fairly common migrant
Winter: not recorded

The Least Sandpiper breeds from Alaska across the low arctic and taiga regions to Newfoundland (Godfrey 1966). In Alberta it is a regular spring and autumn migrant (Salt and Salt 1976).

In Jasper this species is a fairly common autumn migrant, especially in the lower Athabasca River valley where 14 of 15 observations were recorded. There are seven records from Banff since 1978, four from the Clearwater River valley.

There is only a single record of least sandpipers during spring migration: two were seen at Mile 18 Pond on 28 May 1977 (DJK).

Autumn migration is during August. Peak migration is mid August. Earliest record is 27 July 1979 at Lake Annette. Maximum recorded count is 30 on 10 August 1979 at Mile 18 Pond. Latest record is 2 September 1979 at Wigmore Lake.

HABITAT

Mudflats, sandy beaches, and edges of ponds in the montane and lower subalpine ecoregions.

BAIRD'S SANDPIPER *Calidris bairdii* **BASA**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: not recorded
Autumn: fairly common migrant
Winter: not recorded

The Baird's Sandpiper breeds in the high arctic of Siberia, Alaska and Canada (Godfrey 1966). It is a common spring and autumn migrant throughout Alberta except in the mountains (Salt and Salt 1976).

In Jasper, this species is a fairly common autumn migrant in the lower Athabasca River valley, especially at Mile 18 Pond and Jasper Lake. In Banff it has been recorded only 3 times: 1 was seen on 13 September 1979 at Snowflake Lake, 1 was seen on 18 September 1979 at Wigmore Lake, and 2 were seen in Larch Valley on 14 September 1980.

Autumn migration is during August and early September. Peak migration is late August. Earliest record is 21 August 1979 at Jasper Lake. Maximum recorded count is 45 on 29 August 1979 at Jasper Lake. Latest record is 18 September 1980.

HABITAT

Sandy beaches, mud flats, lake and pond edges in the montane (6 of 8 records) and, rarely, lower subalpine and upper subalpine ecoregions.

PECTORAL SANDPIPER *Calidris melanotos* **PESA**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: not recorded
Autumn: fairly common migrant
Winter: not recorded

The Pectoral Sandpiper breeds in eastern Siberia and the coastal drainages of Alaska and northern Canada (Godfrey 1966). It is a regular spring and autumn migrant through Alberta, being less common in the mountains than elsewhere (Salt and Salt 1976).

In Banff and Jasper this species occurs regularly in the lower Athabasca River valley, especially at Pocahontas Ponds and Mile 18 pond, but there are a few records from elsewhere in the Front Ranges. It has been recorded twice at Wigmore Lake and once in each of the lower Bow River, middle Bow River, Mistaya River, Panther River, Pipestone River and Rocky River valleys.

There are only two spring migration records: one was seen at Cottonwood Slough on 11 May 1972 (Jasper warden files) and ten were seen at Pocahontas Ponds on 9 May 1977 (JDS).

There is a single record during the breeding season: one was seen on the Quoin above Mowitch Creek on 1 July 1980 (KVT).

Autumn migration is during August and early September. Peak migration is in late August. Earliest record is 28 July 1979 on Panther Mountain. Maximum recorded count is 62 on 24 August 1979 at Pocahontas Ponds. Latest record is 11 October 1975 at Pocahontas Ponds.

HABITAT

Pectoral Sandpipers occur in sedgy mudflats and along lakeshores in the montane, lower subalpine and upper subalpine ecoregions with the majority of sightings (7 of 13 since 1975) being in the montane ecoregion. There are only two July records; both of these are of single birds in rocky alpine meadows with white dryas, dwarf willow, and sedges.

DUNLIN *Calidris alpina* **DUNL**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: not recorded
Autumn: not recorded
Winter: not recorded

The Dunlin breeds in arctic drainages of North America, Britain, Greenland and Eurasia (Godfrey 1966). It is a rare migrant through Alberta, commoner in autumn than spring (Salt and Salt 1976).

In Jasper this species has been recorded only once: an individual was observed on 26 May 1976 at Talbot Lake (GLH).

HABITAT

"Muddy shores, mud flats and sand or gravel beaches" (Godfrey 1966). The Jasper record was on a mud shoreline in the montane ecoregion.

SHORT-BILLED DOWITCHER *Limnodromus griseus* **SHDO**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare migrant
Winter: not recorded

The Short-billed Dowitcher breeds locally from southern Alaska east to Labrador (Godfrey 1966). In Alberta it breeds from Edmonton north (Salt and Salt 1976).

In Banff and Jasper this species is a very rare autumn migrant. There are only five records: nine were seen on 6 August 1977 at Mile 18 Pond (DJK), one was seen on 22 August 1978 at Waterfowl Lakes (MED), one was seen on 1 September 1979 at Wigmore Lake (HFC), one was seen on 12 September 1977 at Edna Lake (DJK), and 31 were seen on 17 September 1977 also at Edna Lake.

HABITAT

Three of the Jasper records are from montane lake shores with exposed mud flats. The two Banff records are from lower subalpine lake edges.

LONG-BILLED DOWITCHER *Limnodromus scolopaceus* **LODO**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: not recorded
Autumn: uncommon migrant
Winter: not recorded

The Long-billed Dowitcher breeds in parts of Siberia, northwestern coastal Alaska, and northern Mackenzie (Godfrey 1966). In Alberta it is a regular spring and autumn migrant.

In Banff and Jasper this species has been recorded three times at Vermilion Lakes (Gordon 1975) and occurs regularly along the lower Athabasca River in August, but is very rare elsewhere. There are two records from Wigmore Lake of individuals seen on 16 July 1979 and 16 October 1979, and there is a record from Castleguard Meadows on 16 August 1970 (Gordon 1975).

There are only two spring records: an unspecified number were seen at Vermilion Lakes on 4 May 1974 (Gordon 1975) and three were seen at Talbot Lake on 20 May 1979 (MAS).

Autumn migration lasts from late July to mid October. Earliest record is 8 July 1971 (Gordon 1975). Maximum recorded count is 20 on 11 October on the Athabasca River flats and latest record is 14 on 16 October 1979 at Mile 18 Pond.

HABITAT

Long-billed Dowitchers frequent mudflats and sedgy lake shores in the montane and lower subalpine ecoregions.

STILT SANDPIPER *Micropalma himantopus* **STSA**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: fairly common migrant
Winter: not recorded

The Stilt Sandpiper is an arctic species that breeds in coastal drainages of Alaska and the Northwest Territories east to northern Manitoba and Ontario (Godfrey 1966). In Alberta it is a regular spring and autumn migrant, especially in the northern part of the province (Salt and Salt 1976).

In Jasper this species is an uncommon autumn migrant but it has not been recorded in Banff. It is seen most regularly at Mile 18 and Pocahontas Ponds.

Autumn migration is in late August. Earliest record is 21 August 1951 at Snaring (Cowan 1955). Maximum recorded count is 29 on 25 August 1979 at Pocahontas and Mile 18 Ponds. Latest record is 26 August 1979 at Mile 18 Pond (DJH).

HABITAT

The Stilt Sandpiper frequents grassy and sedgy lakeshores in the montane ecoregion.

BUFF-BREASTED SANDPIPER *Tryngites subruficollis* **BUSA**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare migrant
Winter: not recorded

The Buff-breasted Sandpiper breeds locally in northern Alaska and the western Canadian arctic (Godfrey 1966). In Alberta it is a regular spring and autumn migrant, especially in the central part of the province (Godfrey 1966).

There are only two records of this species in Jasper: an individual was seen on 26 August 1979 at Jasper Lake and again at the same location on 29 August (DJH).

HABITAT

The Jasper sighting was in sparse grassy vegetation and driftwood along a sandy lakeshore in the montane ecoregion.

MARBLED GODWIT *Limosa fedoa* **(b?)** **MAGO**

STATUS AND DISTRIBUTION

The marbled godwit breeds in the prairies of western Canada and the northwestern USA, and occurs in most of the prairie and parkland regions of Alberta (Godfrey 1966).

In Jasper this species is considered hypothetical. There is a single record. Warden H. Herfet reported finding a nest at Wabasso Lake on 6 June 1972 (Jasper warden files). This is far from the species' normal range and habitat.

HABITAT

Marbled godwits usually frequent "... Grasslands of the prairie and the edges of prairie sloughs and lakes" (Godfrey 1966).

AMERICAN AVOCET *Recurvirostra americana* **AMAV**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: not recorded
Autumn: very rare visitor
Winter: not recorded

The American Avocet breeds from the southern prairies of Canada south to near the Mexico border (Godfrey 1966). In Alberta it occurs in the parkland and prairie regions east and south of Edmonton (Salt and Salt 1976).

There are only 2 records of this species in Banff, and none in Jasper. One was seen on 29 April 1959 on the Bow River near Banff townsite (Gordon 1975). One was seen on 20 August 1978 at Ghost Lakes (Rob Gardner, Banff Interpretive Service).

HABITAT

American Avocets normally occur on "... Shores and flats of sparsely vegetated lakes and sloughs, especially alkaline ones" (Godfrey 1966) and their occurrence in Banff is consequently highly unusual.

RED PHALAROPE *Phalaropus fulicarius* **REPH**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: not recorded
Autumn: not recorded
Winter: not recorded

The Red Phalarope breeds in the arctic coast regions of Canada, Alaska, and Eurasia (Godfrey 1966). It is a very rare visitor to Alberta, usually during autumn migration.

There is only one record of this species in Banff: 4 were seen on 23 May 1953 in the upper North Saskatchewan River valley (Banfield 1954a).

HABITAT

The red phalarope migrates mainly on "... the open sea... more rarely freshwater bodies of the interior" (Godfrey 1966).

WILSON'S PHALAROPE *Steganopus tricolor* **WIPH**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: very rare visitor
Autumn: very rare migrant
Winter: not recorded

Wilson's Phalarope breeds from the southern edge of the boreal region south locally through the prairies and western mountains to the central States, and in southern Ontario (Godfrey 1966). It breeds throughout Alberta except in the extreme northeast and in the mountains (Salt and Salt 1976).

In Banff and Jasper this species occurs regularly in the lower Bow River valley, especially the Vermilion Lakes, and in the lower Athabasca River valley, but it has not been recorded elsewhere.

Spring migration is during May. Earliest record is 7 May 1977 at Vermilion Lakes. Maximum recorded count is four on 15 May 1977 at Talbot Lake. Latest spring record is 14 on 29 May 1977 in Banff.

There is a single record of a female at the Jasper sewage lagoon on 20 June 1979 (DJH), but it is unlikely that the species breeds in Banff or Jasper.

Autumn migration is during late August; there are only three records. Two were seen on 20 August 1976 in the Valley of Five Lakes, four were seen on 29 August 1978 in the lower Cascade River valley (MED), and 12 were at Maligne Lake on 24 August 1976 (DMI).

HABITAT

All records are from ponds and lake edges near emergent vegetation in the montane ecoregion.

NORTHERN PHALAROPE *Lobipes lobatus* **NOPH**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: very rare visitor
Autumn: rare migrant
Winter: not recorded

The Northern Phalarope breeds in the arctic and northern taiga of North America, Eurasia and Greenland (Godfrey 1966). In Alberta it is a regular spring and autumn migrant except in the mountains (Salt and Salt 1976).

In Jasper this species is a regular autumn migrant in the lower Athabasca River valley and has been observed once at Caribou Lake near Blue Creek and once at Medicine Lake. It has been recorded only 4 times in Banff. Eight were seen on Vermilion Lakes on 29 May 1977 (McIvor and McIvor 1980). Unspecified numbers were seen on 5 June 1966 at Johnson's Lake and in "July 1964" at Rainy Bay (Gordon 1975). Two were seen near Redoubt Lake on 6 August 1977 (MED).

Spring migration is during May. Earliest record is 13 May 1946 at Edith Lake (Cowan 1955). Maximum recorded count is 23 on 22 May 1978 at Talbot Lake. Latest record is 23 May 1946 at Talbot Lake.

Autumn migration is during August and early September. Peak migration is late August. Earliest record is 8 August 1978 in the Athabasca River valley. Maximum recorded count is 12 on 25 August 1979 at the Jasper sewage lagoon. Latest record is 11 September 1978 on the lower Athabasca River.

HABITAT

Of 12 records, nine were in the montane, and one in each of the lower subalpine, upper subalpine and alpine ecoregions. Northern Phalaropes frequent ponds, lakes and river backwaters.

PARASITIC JAEGER *Stercorarius parasiticus* **PAJA**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare visitor
Winter: not recorded

The Parasitic Jaeger breeds in arctic regions of North America, Eurasia, Greenland, Iceland and Scotland (Godfrey 1966). In Alberta it is a casual wanderer (Salt and Salt 1976).

There are three records in Banff and Jasper. One was seen on 15 August 1978 in the Whirlpool River valley (MAS), one was seen five days later at Lake Minnewanka (Rob Gardner, Banff Interpretive Service) and one was seen on 28 August 1976 at the Snaring River (D.V.Weseloh).

HABITAT

"In migration open ocean and coasts; rarely large lakes of the southern interior" (Godfrey 1966). The two records in Banff and Jasper were of a bird flying over a lower subalpine alluvial willow meadow and of one on a montane lake.

LONG-TAILED JAEGER *Stercorarius longicaudus* **LOJA**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare visitor
Winter: not recorded

The Long-tailed Jaeger is circumpolar, breeding across arctic Canada (Godfrey 1966). In Alberta this species is rare but may be expected only as larger lakes especially in northern Albera (Salt and Salt 1976). There are two recordsin Banff and Jasper: one at the Jasper sanitary landfill on 28 August 1976 (D.V.Weseloh) and one at Lake Minnewanka in July 1978 (R.Gardner).

HERRING GULL *Larus argentatus* **HEGU**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: not recorded
Autumn: uncommon migrant
Winter: not recorded

The Herring Gull breeds in forested and coastal areas of Canada, northeastern U.S.A., Greenland, Iceland, Europe and Siberia (Godfrey 1966). It breeds in northeastern Alberta south to Namur and Lower Therien Lakes (Salt and Salt 1976).

In Banff and Jasper this species has been recorded once along the lower Brazeau River and once at Isaac Creek and there are only three records from Banff, all in the lower Bow River. It is most commonly seen at the Jasper Sanitary Landfill and on the Athabasca River nearby.

Spring migration is during late April and early May. Earliest record is 22 April 1978 in the lower Bow River and maximum recorded count is four on the same date. Latest record is 4 June 1946 on the Devona trail (Banfield).

Autumn migration lasts from August until late October. Earliest record is 29 July 1977 in the lower Bow River valley. Maximum recorded count is 196 on 16 October 1978 at the Jasper sanitary landfill. Latest record is 2 November 1978 in the lower Athabasca River valley.

HABITAT

Herring Gulls frequent garbage dumps, rivers and lakes in the montane and lower subalpine ecoregions.

THAYER'S GULL *Larus thayeri* **THGU**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare migrant
Winter: not recorded

Thayer's Gull breeds in the arctic islands of North America and on Greenland (Godfrey 1966). There are very few records of the species from the Prairie Provinces (Salt and Salt 1976).

In Jasper this species is a very rare migrant; there is only one record of three seen at the Jasper sanitary landfill on 6 September 1976 (D.V. Weseloh). There are no records from Banff.

HABITAT

"Primarily a saltwater gull, but migrants or non-breeders visit freshwater lakes and rivers..." (Godfrey 1966). In Jasper this species was observed at a sanitary land fill in the montane ecoregion.

CALIFORNIA GULL *Larus californicus* **CAGU**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon visitor
Autumn: common migrant
Winter: not recorded

The California Gull breeds in the Great Plains of North America from Great Slave Lake south to North Dakota (Godfrey 1966). In Alberta there are breeding colonies on the larger lakes in the eastern half of the province, and non-breeders occur throughout the province.

In Banff and Jasper this species is largely confined to the valleys of the Athabasca River and Bow River, but there are two records from the Sunwapta River and 1 each from the north fork of the Brazeau River and lower Cascade River valleys.

Spring migration is in late April and May, peaking in early May. Earliest record is 22 April 1978 in the lower Bow River valley. Maximum recorded count is 50 on 7 May 1946 at Lake Edith (Cowan 1955).

Up to 10 non-breeding individuals in Jasper and 35 in Banff have been recorded during the summer, usually at sanitary landfills or on the Athabasca River, Bow River and Jasper Lake.

Autumn migration lasts from August until late October, peaking in late August. Maximum recorded count is 150 on 18 August 1977 at the Banff sanitary landfill. Latest record is 28 October 1978 at the Jasper sanitary landfill.

HABITAT

California Gulls frequent sanitary landfills, picnic areas, rivers and lakes in the montane ecoregion (18 of 23 records) and are occasionally seen along lower subalpine rivers and lakes (3 records). Closure of the Banff sanitary landfill in 1980 greatly reduced California Gull numbers in the lower Bow River valley.

RING-BILLED GULL *Larus delawarensis* **RIGU**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon visitor
Autumn: common migrant
Winter: not recorded

The Ring-billed Gull breeds from the prairies, St. Lawrence River and Atlantic Coast of Canada south to Idaho, Colorado and New York (Godfrey 1966). It breeds throughout much of Alberta, occurring elsewhere in the province as a non-breeder.

In Banff and Jasper there is one record each from the lower Brazeau River and the Sunwapta River, and 34 records from the Athabasca River, Bow River, and Lake Minnewanka, reflecting the high use of the Banff and Jasper sanitary landfills by this species.

Like the California Gull, with which it frequently associates, this species migrates in April and May, peaking in early May. Earliest record is 20 April 1976 on the lower Athabasca River and maximum count is 40 on 11 May 1979 at the Jasper sanitary landfill.

In Jasper up to 30 and in Banff up to 240 non-breeding Ring-billed Gulls have been recorded in summer in the vicinity of landfills.

Autumn migration lasts from August until early November, peaking in August. Maximum recorded count is 364 on 29 July 1977 at the Banff sanitary landfill. Latest record is 2 November 1978 at the Jasper sanitary landfill.

HABITAT

Ring-billed Gulls frequent dumps, picnic areas, rivers and lakes in the montane ecoregion. Only four of 36 records since 1975 were in the lower subalpine ecoregion.

MEW GULL *Larus canus* **MEGU**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: very rare visitor
Autumn: very rare migrant
Winter: not recorded

The Mew Gull breeds from the Mackenzie River drainage north and west to the Arctic and Pacific Oceans, and in northwestern B.C. (Godfrey 1966). In Alberta it is a casual migrant except in the northeastern corner of the province where it is a regular summer visitor (Salt and Salt 1976).

There is only one record in Banff: two were photographed on 7 September 1979. There are four Jasper records: two adults were seen at Amethyst Lake on 13 July 1976 (A.Strepniewski), one was seen at Buffalo Prairie on 27 May 1951 (Banfield 1956). Two were reported on Medicine Lake on 23 July 1944 (Cowan 1955) and one was seen at the Jasper sanitary landfill on 6 September 1976 (D.V. Weseloh).

HABITAT

"In nesting season, marshes, lakes and rivers. In migration... mudflats, beaches, garbage dumps, often with the larger gulls." (Godfrey 1966).

FRANKLIN'S GULL *Larus pipixcan* **FRGU**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: very rare visitor
Autumn: very rare migrant
Winter: not recorded

Franklin's Gull breeds in the prairie region of North America (Godfrey 1966). In Alberta there are colonies on most large lakes of the prairies and northeastern part of the province (Salt and Salt 1976).

In Banff this species has been recorded twice, however Gordon (1975) says that it is "... usually seen on Vermilion Lakes on migration". An unspecified number was observed on Lake Minnewanka on 3 May 1974 (Gordon 1975) and 1 was seen on Vermilion Lakes on 4 August 1975 (Bow Valley Naturalists 1978).

In Jasper this species has been recorded three times on spring migration. An unspecified number was seen at Athabasca Falls on 14 May 1969 (Jasper warden files). A flock of 30 was at Talbot Lake on 15 May 1977 (JRS) and 200 were seen at Maligne Lake on 9 June 1971 (Jasper warden files). There are two autumn records: one was seen at Jasper sanitary landfill on 4 September 1979 (KVT), and 15 there on 16 August 1970 (D.V. Weseloh)

There is a risk of observers confusing this prairie species with Bonaparte's Gulls which migrate more frequently through Banff and Jasper.

HABITAT

Franklin's Gulls usually frequent "... prairie lakes and marshes; grassy fields and ploughed land... " (Godfrey 1966). Three of the 6 records in Banff and Jasper are from montane lakes. One is from an upper subalpine lake, 1 from a dump, and 1 is not specified.

BONAPARTE'S GULL *Larus philadelphia* **BOGU**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: very rare visitor
Autumn: rare migrant
Winter: not recorded

Bonaparte's Gull breeds throughout the boreal forest regions of North America at least as far east as Quebec (Godfrey 1966). It breeds in most of northern Alberta (Salt and Salt 1976).

In Banff and Jasper this species is an irregular migrant in the larger Front Range valleys. It occurs most regularly at Talbot Lake, Jasper Lake and Vermilion Lakes and has been recorded once at Isaac Creek on 7 May 1980 (RLM). Of 13 records since 1975, 10 were from the Athabasca River valley.

Spring migration is in May. Earliest record is 27 April 1976 at Vermilion Lakes (McIvor and McIvor 1980). Maximum count is 120 on 9 May 1970 at Talbot Lake. Latest record is 27 May 1978 at Talbot Lake.

Autumn migration is in August. Earliest record is five on 29 July 1970 at the Banff land fill (D.V. Weseloh). Maximum recorded count is eight on 17 August 1978 on the Athabasca River. Latest record is 27 September 1971 at Vermilion Lakes (Gordon 1975).

HABITAT

Although Bonaparte's Gulls migrate at the same time as the white headed gull species, they rarely associate with them and are never seen at sanitary landfills. All but one record from a lower subalpine river floodplain are from lakes and rivers in the montane ecoregion.

SABINE'S GULL *Xema sabini* **SAGU**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: very rare visitor
Autumn: very rare migrant
Winter: not recorded

The Sabine's Gull breeds from Spitsbergen through Greenland and North America to Siberia (Godfrey 1966). In Alberta it is a rare, but evidently regular, spring and autumn migrant (Salt and Salt 1976).

In Banff and Jasper it is a very rare spring and autumn migrant, being limited to 5 records from the lower Athabasca River valley and 1 from Vermilion Lakes.

There are only four spring records from Jasper. One was seen on 13 June 1968 at Lake Mildred, two were seen on 28 June 1968 at Lake Edith, on 4 July 1970 on the lower Athabasca River, and on an unspecified date 1969, at Lake Mildred (Wolford 1972). Two were seen on the lower Athatbasca River on 4 July 1970 (Wolford 1972).

There are only two autumn records from Banff and Jasper. Three were seen on 17 September 1972 on Vermilion Lakes (Gordon 1975) and one was reported on 7 October 1978 at Jasper Lake.

HABITAT

All records of Sabine's Gulls in Banff and Jasper are from lakes and rivers of the montane ecoregion. Non-breeders and migrants are usually found on "... coastal waters, rarely on Southern interior freshwater" (Godfrey 1966).

FORSTER'S TERN *Sterna forsteri* **FOTE**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: very rare visitor
Autumn: rare migrant
Winter: not recorded

The Forster's Tern breeds in the Great Plains region of North America (Godfrey 1966). In Alberta it breeds locally in the prairies north to the Edmonton district (Salt and Salt 1976).

This species has been recorded only three times in Banff and once in Jasper. At the Vermilion Lakes, three were seen on 18 May 1974, one on 25 August 1974 and another was seen there on 28 September 1966 (Gordon 1975). One was recorded at Maligne Lake in July 1941.

HABITAT

The three Banff records were all from a montane lake and the Jasper record is from a lower subalpine lake. The usual habitat of the species is "Marshes (in Canada only inland), frequently those bordering lakes" (Godfrey 1966).

COMMON TERN *Sterna hirundo* **COTE**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: rare visitor
Autumn: uncommon migrant
Winter: not recorded

The Common Tern breeds throughout much of the Northern Hemisphere (Godfrey 1966). In Canada it breeds from the Rocky Mountain foothills east to the Atlantic Ocean except in the Arctic (Salt and Salt 1976).

This species occurs mostly in the valleys of the lower Athabasca and Bow Rivers.

Spring migration is during May and early June, the later birds probably being non-breeders. Earliest record is 6 May 1979 at Talbot Lake. Maximum recorded count is 6 on 11 May 1979 at Talbot Lake. Latest record is 15 June 1944 at Talbot Lake (Cowan 1955).

Autumn migration is during September. Earliest record is 6 September 1976 at Talbot Lake. Maximum recorded count is 25 on 6 September 1978 at Talbot Lake. Latest record is 27 September 1966 at Vermilion Lakes.

HABITAT

All records of Common Terns in Banff and Jasper are from montane backwaters and floodplain lakes.

BLACK TERN *Chlidonias niger* **BLTN**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Black Tern breeds throughout much of the Northern Hemisphere and throughout southern Canada except western B.C., the Rocky Mountains, and the Maritimes (Godfrey 1966). In Alberta it breeds throughout the province except in the mountains (Salt and Salt 1976).

In Banff and Jasper this species has been recorded only seven times. All records are from May and June and the valleys of the lower Athabasca and Bow Rivers, except one seen at Snake Indian Lakes.

Earliest record is 25 May 1965 at Vermilion Lakes (Gordon 1975). Another was seen there on 26 May 1973 (Gordon 1975), and one was seen at Talbot Lake on 27 May 1979 (KVT).

There are five June records. On 15 June 1944, four were seen at Talbot Lake and two more were seen on 3 June 1946 (Cowan 1955). On 20 June 1965, four were seen at Banff townsite, on 20 June 1979 one was seen at Mildred Lake (DJH) and on 7 June 1980 one was seen at Snake Indian Lakes (KVT). There is no evidence to suggest that any of these birds were breeding.

HABITAT

The Black Tern frequents shallow marshes and lake edges having extensive beds of emergent vegetation (Salt and Salt 1976). All of the Banff and Jasper records were on shallow montane lakes with sedge and reed beds, except for one record in the lower subalpine ecoregion.

BAND-TAILED PIGEON *Columbia fasciata* **BAPI**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Band-tailed Pigeon breeds in the mountain regions of western North America and South America from southwestern B.C. south to Nicaragua. It has been observed on several occasions in Alberta and once in Saskatchewan but does not nest east of the Rockies (Salt and Salt 1976).

In Jasper there are two records of this species but it has not been reported in Banff. One was seen near Patricia Lake in July 1968 and one at the Whistlers Youth Hostel on 27 June 1973 (Salt and Salt 1976).

HABITAT

Both Jasper records are from forested areas in the montane ecoregion. It usually frequents "... open woodland (both coniferous and deciduous) and edges" (Godfrey 1966).

ROCK DOVE *Columba livia* **(b?)** **RODO**

STATUS AND DISTRIBUTION

Spring: uncommon resident
Summer: uncommon resident
Autumn: uncommon resident
Winter: uncommon resident

The Rock Dove is a Eurasian species that has been naturalized throughout most settled parts of the world (Godfrey 1966). In Alberta it breeds most commonly in settled areas and near farms, and occurs throughout the province (Salt and Salt 1976).

This species is an uncommon permanent resident of Banff and Jasper, occurring almost exclusively around Jasper and Banff townsites. The highest recorded count in Banff is three on 14 December 1976 (McIvor and McIvor 1980) and on 27 May 1979. Ten were observed in Jasper townsite on 4 November 1977 (DJK) and 11 on 16 December 1978 (KVT). In Jasper townsite they occur most regularly at the CNR yards. No nests have been recorded in Banff and Jasper.

HABITAT

The Rock Dove frequents towns, cities, farms and other developed areas. In Banff and Jasper there is one record from a bridge over a river in the montane ecoregion, and all other records are from Banff townsite and Jasper townsite.

MOURNING DOVE *Zenaida macroura* **(B)** **MODO**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: uncommon resident
Autumn: rare migrant
Winter: not recorded

The Mourning Dove is a North American species that breeds throughout southern Canada (Godfrey 1966). In Alberta it nests throughout the province as far north, at least, as Lesser Slave Lake (Salt and Salt 1976).

In Banff and Jasper this species occurs primarily in the valleys of the lower Athabasca and Bow Rivers and, occasionally, other valleys of the Front Ranges. There is one record each from the Clearwater River and lower Red Deer River valleys.

Spring migration is during May and early June, peaking in late May. There is one exceptionally early record from 5 April 1970 at Athabasca Falls (Jasper warden files). The next record is 8 May 1964 at Banff townsite.

There are no recent nest records from Banff and Jasper. However two nests were found near Jasper townsite in 1944 (Cowan 1955) and Mourning Doves are seen

regularly in the valleys of the lower Athabasca and Bow Rivers during the breeding season.

Autumn migration is during August. Maximum recorded count is nine on 19 August 1977 in the lower Bow River valley. Latest record is 9 October 1980 at Banff townsite.

HABITAT

Of 20 records of Mourning Doves since 1975, all but six have been in the montane ecoregion. Alluvial habitats are preferred (13 records) with deciduous and mixed forest (5), deciduous shrubbery (4) and lodgepole pine forest and white spruce forest (2 each) being most important. There are two old nest records, both from Douglas-fir forest (Cowan 1955).

SCREECH OWL *Otus asio* **SCOW**

STATUS AND DISTRIBUTION

The screech owl is a North American species which breeds in Alaska and B.C. and locally in the southern parts of the Canadian provinces (Godfrey 1966). It does not breed in Alberta and has been recorded in the province only three times (Salt and Salt 1976).

There is a single hypothetical record from Banff. An egg in the collection of the Alberta Provincial Museum in Edmonton, collected by Miss Georgina Patrick of Calgary is labelled "Banff". The details of this collection will probably never be known as it was made in 1897.

HABITAT

Screech owls frequent "... open woodlands, groves... and shade trees about houses in backwoods or city" (Godfrey 1966).

GREAT HORNED OWL *Bubo virginianus* **(B)** **GHOW**

STATUS AND DISTRIBUTION

Spring: uncommon resident
Summer: uncommon resident
Autumn: uncommon resident
Winter: uncommon resident

The Great Horned Owl occurs throughout the wooded areas of North America including prairie river valleys (Godfrey 1966). It nests throughout Alberta and is a year round resident (Salt and Salt 1976).

In Banff and Jasper this species is an uncommon permanent resident that occurs in most of the major valleys. It has been recorded 34 times since 1975 by inventory staff, including 3 road kills in the lower Bow River valley.

Although the earliest recorded nest is 9 April 1978 above Vermilion Lakes, it may nest as early as February (Salt and Salt 1976). Earliest fledged young recorded were on 26 May 1972 at Edith Lake (Jasper warden files). There are four breeding records since 1975; however Great Horned Owl nests are not readily located. Cowan's (1955) report

of a die-off in the winter of 1945/46, when eight carcasses were found in Jasper, indicates that Great Horned Owls may occasionally be fairly common.

HABITAT

Of 34 records of Great Horned Owls since 1975, 17 have been in alluvial areas and 13 have been in the montane ecoregion, compared to eight in the lower subalpine and one in the upper subalpine.

LIFE HISTORY

Evidence of predation by Great Horned Owls has been observed on Red squirrel, Steller's Jay and Blue Jay once each. There is a single record of a Great Horned Owl killing a Varying hare, and on 25 April 1977 a nest in a crevice in the cliffs above Vermilion Lakes contained 4 dead Northern flying squirrels (GLH, HFC).

SNOWY OWL *Nyctea scandiaca* **SNOW**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: very rare migrant
Winter: very rare visitor

The Snowy Owl is a circumpolar species that breeds in arctic regions and migrates south irregularly in winter to boreal and temperate regions (Godfrey 1966). In Alberta it is a regular winter species except in the mountains, its numbers varying considerably from year to year (Salt and Salt 1976).

In Banff and Jasper this species is very rare; there are only four records. One was seen on 16 October 1973 at Waterfowl Lakes (Gordon 1975). One was seen on 4 December 1958 at Blue Creek and one on 16 December 1954 at Talbot Lake (Jasper warden files). There is a single record from 9 July 1975 at Lake Louise, reported by warden J. Rimmer (Banff warden files).

HABITAT

Snowy Owls frequent "... open places such as fields, marshes, coasts, shores of lakes and large rivers" (Godfrey 1966). In Banff and Jasper there are two records from lakes and one from an open lower subalpine alluvial meadow.

HAWK OWL *Surnia ulula* **(B)** **HAOW**

STATUS AND DISTRIBUTION

Spring: very rare resident
Summer: very rare resident
Autumn: very rare resident
Winter: rare resident

The Hawk Owl breeds thoughout Canada from the northern taiga south to the Rocky Mountains and the northern edge of the aspen parkland and deciduous forest regions (Godfrey 1966). It breeds locally in the northern half of Alberta and the mountains (Salt and Salt 1976).

Hawk Owls are very rare in Banff and Jasper except in winter. There are only two summer records from Jasper; one was collected by Spreadborough on 14 June 1898, and one was seen by Macoun on 27 August 1917 (Cowan 1955). In Banff Hawk Owls have been recorded on 20 July 1885 at Lake Louise (Clarke and Cowan 1945) and on 1 August 1972 at Sawback lookout tower (Gordon 1975). There is a record from Chateau Lake Louise on 28 June 1975. During the summers of 1975 to 1978 inclusive families of fledged young were seen in the Vermilion Pass burn. Sanson found a nest near Simpson Pass in 1913 (Clarke and Cowan 1945). Additonal records are three on 7 August 1975 at the Crowfoot Glacier Lookout (GLH), one on 17 October 1965 at Moraine Lake, one on 19 September 1979 in the Cascade valley (HFC) and one on 15 October 1977.

There are 14 winter records of Hawk Owls in Banff and Jasper. Five are from the lower Athabasca River valley and 5 are from the Bow River valley.

HABITAT

In Banff and Jasper Hawk Owls have only been found nesting in a recent burn with pockets of unburned spruce/fir forest. At other seasons they have been observed in white spruce forest in montane wetlands and in subalpine spruce/fir forest.

The usual habitat of this species is "... northern muskegs and old burned areas" (Salt and Salt 1976).

PYGMY OWL *Glaucidium gnoma* **(B)** **PYOW**

STATUS AND DISTRIBUTION

Spring: uncommon resident
Summer: uncommon resident
Autumn: uncommon resident
Winter: uncommon resident

The Pygmy Owl breeds from the Rocky Mountains west to the Pacific, and from Alaska south to Guatemala (Godfrey 1966). Its Alberta status is poorly known but it probably breeds throughout the Rocky Mountains (Salt and Salt 1976).

In Banff and Jasper this species has been recorded most frequently in the lower Bow River valley. In Banff it fluctuates in abundance from year to year, although it is usually rare it may be fairly common in some years. Beginning in December 1976, Pygmy

Owls were seen regularly in the lower Bow River valley, individuals being seen at Two Jack Lake, Banff townsite, Bankhead, the Fenland Trail, Skoki, Lake Louise and Carrot Creek, Tunnel Mountain; and nests were found at the latter two locations in spring of 1977. In 1978 Pygmy Owls were recorded only on Tunnel Mountain and no nests were found, and in 1979 the species was recorded only three times.

In spring of 1980 Pygmy Owls were present but rare in Jasper, single birds being heard in the Smoky River, lower Athabasca River, and lower Brazeau River valleys during 8 nights of owl surveys in late April and early May.

Two nests have been found since 1975, all in Banff. The earliest nest was 25 April 1977 on Tunnel Mountain, and young were first heard in the nest on 5 June (McIvor and McIvor 1980). Pygmy Owls occur irregularly in Banff townsite and Jasper townsite during the winter months; from 1975 to 1977 from one to three were recorded annually on Banff's Christmas bird counts. One was seen in Jasper townsite on 14 January 1980, carrying a House Sparrow.

HABITAT

Of 19 records for which habitat was noted, nine were in lodgepole pine forest, three in white spruce, two in aspen forest, and two in developed townsites.

BURROWING OWL *Speotyto cunicularia* **BUOW**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Burrowing Owl breeds in grassland and desert regions of North America and South America (Godfrey 1966). In Alberta it breeds locally and irregularly south of Munson and Provost, and east of Calgary (Salt and Salt 1976).

There are only 2 records of Burrowing Owls in Banff and Jasper. One was seen in Banff townsite on 4 May 1973 (Gordon 1975) and 1 was found dead in Jasper townsite and turned in to the Jasper warden service on 16 June 1979. The specimen was forwarded to the Alberta Provincial Museum. Both these records are exceptional, Banff and Jasper being well outside the usual range and habitat of this species.

HABITAT

The Burrowing Owl usually frequents "... open short-grass treeless country" (Godfrey 1966).

BARRED OWL *Strix varia* **(B)** **BAOW**

STATUS AND DISTRIBUTION

Spring: rare resident
Summer: rare resident
Autumn: rare resident
Winter: rare resident

The Barred Owl breeds from the boreal regions of Canada south, through the wooded parts of the USA and Mexico to Guatamala and Honduras (Godfrey 1966). In Alberta it breeds locally throughout much of the middle third of the province and south in the foothills at least as far as Calgary.

Although the Barred Owl is "... considered to be a permanent resident throughout its range... " (Salt and Salt 1976), it has not been recorded in Banff and Jasper in winter. It occurs regularly near Jasper townsite especially along the lower Miette River, where it has nested (Roy Richards, pers. comm.), and near Cottonwood Slough (R. Richards) and Pyramid Lake (R. Salt pers. comm., JRS). It has been recorded twice near North Saskatchewan River Crossing (MED,MJD), twice near Vermilion Lakes Banff interpretive staff, once at Lake Annette (KVT), and once near Maligne Canyon (JRS).

Two nests have been reported near Jasper townsite (JRS, Roy Richards).

HABITAT

Mature, riparian forest of white spruce and balsam poplar in the montane ecoregion is preferred by Barred Owls. There is one record from mature Douglas-fir forest near Lake Annette.

GREAT GRAY OWL *Strix nebulosa* **(b?)** **GGOW**

STATUS AND DISTRIBUTION

Spring: very rare resident
Summer: very rare resident
Autumn: very rare resident
Winter: very rare resident

The Great Gray Owl breeds throughout much of the Northern Hemisphere including much of the boreal and cordilleran regions of Canada (Godfrey 1966). It occurs throughout the northern half of Alberta (Salt and Salt 1976).

Great Gray Owls have been observed 8 times since 1975 in Banff and Jasper, with 5 of these records being during August and September. It has been recorded three times in the Bow River valley, twice in the lower Brazeau River valley, and once in each of the Baker Creek, lower Cascade River and lower Red Deer River valleys. In addition there are two roadkills from the Trans Canada Highway (KAM, R.Taylor). Although Cowan (1955) could account for only two records since 1891 in Jasper, Great Gray Owls were "... observed by Mrs. Jefferson in the vicinity of Jasper, not common... " (park checklist dated 1947, Jasper park warden files).

Although there are no nesting records in Banff and Jasper, Great Gray Owls have nested in Kootenay National Park (Van Tighem 1977) and along the foothills of the

Rockies east of Banff and Jasper (Salt and Salt 1976). Great Gray Owls were observed regularly near Willow Creek in 1972 (Carbyn 1972a) and probably nested in the area.

HABITAT

Coniferous or mixed coniferous/deciduous forest adjacent to meadows, wetlands or other openings, in the montane (3 records) and lower subalpine (5 records) ecoregions. There are two records of Great Gray Owls found dead on highways in the Bow River valley.

LONG-EARED OWL *Asio otus* **(B)** **LOOW**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare resident
Autumn: not recorded
Winter: not recorded

The Long-eared Owl is found throughout much of the Northern Hemisphere, breeding in northern Africa, most of Eurasia, and from boreal regions of Canada south to the southern U.S.A. (Godfrey 1966). It breeds throughout Alberta south of Grimshaw except in the mountains (Salt and Salt 1976).

No Long-eared Owls have been recorded in Jasper, and there are only four records from Banff, all from the Bow River valley. One was seen on 11 June 1975 near Hillsdale Meadow (DJK), one on 29 and 30 May 1976, one on 29 May 1977 at Vermilion Lakes (McIvor and McIvor 1980), and a nest with five eggs was found at Muleshoe Lake on 2 May 1976 (GLH). This latter record suggests that Long-eared Owls may be a more regular summer resident then the few records of this quiet, shrubbery-loving species would indicate.

HABITAT

Long-eared Owls usually frequent "thick, almost impenetrable tangles of brush... " (Salt and Salt 1976) and "... denser parts of woods (not necessarily extensive) and copses, probably preferring coniferous or mixed wood... " (Godfrey 1966).

In Banff records are from dense willow shrubbery in an alluvial wetland, open spruce forest with clumps of dense willow on a river floodplain, and mixed spruce/aspen forest with a grassy understory on an alluvial fan, all in the montane ecoregion.

SHORT-EARED OWL *Asio flammeus* **SHOW**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: very rare visitor
Winter: rare visitor

The Short-eared Owl breeds throughout most of the northern hemisphere and all of Canada except the high Arctic (Godfrey 1966). It has not been found nesting in the Rocky Mountains (Salt and Salt 1976).

There are about thirteen records of Short-eared Owls in Banff and Jasper, all but three from the fall migration period which lasts from September into early December. The earliest record is 27 September 1952 (Jasper warden files) and the latest record is 11 December 1951 at Snaring (Jasper warden files). There are three summer records: one on 14 June 1946 at Signal Mountain, two on 25 June 1980 in the lower Athabasca River valley and one in August 1978 on the Castleguard Meadows (GLH, N. Colgan).

HABITAT

All records of Short-eared Owls in Banff and Jasper are from grasslands and shrubby wetlands on alluvial areas, with the exception of three records from alpine meadows. Of thirteen records, seven are from the montane ecoregion, four from the alpine, and 1 from each of the lower subalpine and upper subalpine.

BOREAL OWL *Aegolius funereus* **(B)** **BOOW**

STATUS AND DISTRIBUTION

Spring: uncommon resident
Summer: rare resident
Autumn: rare resident
Winter: rare resident

The Boreal Owl is a circumboreal species that breeds throughout northern Canada (Godfrey 1966). It breeds in the northern half of Alberta south as far as Edmonton, Hastings Lake and Banff (Salt and Salt 1976).

Like many owls, the Boreal Owl is generally more common in Banff and Jasper than the few observations would seem to indicate. During April and May when Boreal Owls are most vocal they are heard in most subalpine valleys of Jasper; at least six were calling along Medicine Lake on 1 May 1980, and individuals were observed in the Smoky, Athabasca, Rocky and Brazeau valleys during May 1980. It has also been recorded in the vicinty of Jasper townsite and in the middle Bow valley. There were "....several holes occupied by these owls near Hillsdale cabin...." in May 1953 (Banfield 1954a) but none were seen or heard in the area in spring 1980; like other small owl species Boreal Owls are probably subject to marked fluctuations in abundance.

A nest at Mowitch Creek on 29 June 1980 contained eggs that were just beginning to hatch. No other nests have been recorded.

HABITAT

Mature coniferous forests in the lower subalpine and montane ecoregions, particularly Engelmann spruce–subalpine fir with adjacent meadows or clearings. The only nest record is from mixed pine/spruce forest at the edge of a lower subalpine alluvial shrub meadow.

SAW-WHET OWL *Aegolius acadicus* **(B)** **SAOW**

STATUS AND DISTRIBUTION

Spring: uncommon resident
Summer: uncommon resident
Autumn: not recorded
Winter: not recorded

The Saw-whet Owl breeds across southern Canada and throughout much of the US (Godfrey 1966). It breeds throughout southern Alberta north to the Athabasca River and Valleyview (Salt and Salt 1976).

Although there are no records in Banff and Jasper before 1967, Saw-whet Owls were found throughout the lower Athabasca River valley during surveys from 24 to 29 April 1980; during this period at least 11 individuals were located. This species probably fluctuates in abundance from year to year but is more widespread than the paucity of records would indicate. There are seven records from the lower Bow River valley and one from each of the Alexandra River, lower Cascade River, lower Brazeau River and Siffleur River valleys.

A possible nest was found in Banff on 3 March 1967 at Duthill (Gordon 1975) in lower Bow River Valley, and Saw-whet Owl were observed here in 1968 and 1969. Another nest is reported from about mile 1 on highway 1A west of Banff (H.Flygare).

HABITAT

Saw-whet Owls occur in deciduous (6 records out of 16) and mixed forests (7) and rarely in coniferous forest. The montane ecoregion is where the majority of Saw-whet Owls occur (14) and there are no records from the upper subalpine and alpine, nor from the valleys of the Main Ranges.

COMMON NIGHTHAWK *Chordeiles minor* **(B)** **CONI**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

The Common Nighthawk breeds from subarctic Canada and Alaska south to Central America (Godfrey 1966), and occurs throughout Alberta (Salt and Salt 1976).

This species is an uncommon but regular breeding species, especially in the low-elevation valleys of the Athabasca River, lower Bow River and lower Red Deer River.

Common Nighthawks are late migrants, arriving in Banff and Jasper in late May, after most other migrants are already starting to nest. Earliest record is 24 May 1974 in Jasper (Cowan 1955). No more than two have been recorded at any one time in the spring.

There are only two nests recorded, both in Banff. Earliest recorded nest is 27 June 1977 at Carrot Creek. Hatched young were seen at this nest on July 18. Another nest had 2 eggs in it on 20 July 1939 (Clarke and Cowan 1945).

Autumn migration is in late August and early September. The maximum number recorded at any time during autumn migration is one. Latest record is 5 September 1978 at Jasper townsite.

HABITAT

The Common Nighthawk occurs most regularly in open habitats in the montane (13 records out of 22) and lower subalpine (7 records). Lodgepole pine savannah, montane meadows, and disturbed sites such as townsites, campgrounds and gravel quarries are favoured habitats.

BLACK SWIFT *Cypseloides niger* **(B)** **BLSW**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: fairly common resident
Autumn: fairly common migrant
Winter: not recorded

The Black Swift breeds in western North America from Alaska south to Costa Rica (Godfrey 1966). It occurs locally throughout the Rocky Mountains of Alberta but only two nesting colonies are known in the province (Salt and Salt 1976).

There are nesting colonies at Johnston's Canyon in Banff and Maligne Canyon in Jasper, and a possible colony at Sunwapta Falls, although no nests have been found there. Banfield (Jasper warden files) reports a nest in a cave above Brazeau Lake in August 1953.

Black Swifts are late migrants, arriving in Banff and Jasper in mid June. The earliest record is 8 June 1977 at Sunwapta Falls. Maximum recorded count is 25 on 27 August 1952 at Whistler Creek. Up to 12 adult Black Swifts have been recorded at the Maligne Canyon colony (MAS, 31 July 1978). In Banff, there were at least 8 and possibly 10 active nests in July 1978 at Johnston's Canyon (GLH,MED). Of these nests 6 were at the Middle Falls and the remainder were scattered downstream to the Lower Falls.

RUBY-THROATED HUMMINGBIRD *Archilochus colubris* **RTHU**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: not recorded
Autumn: not recorded
Winter: not recorded

The Ruby-throated Hummingbird breeds from southern Canada south to Costa Rica, east of the Rocky Mountains (Godfrey 1966). It breeds locally in south-eastern and central Alberta and the Peace River district (Salt and Salt 1976).

There is only a single record of this species in Jasper; a male was seen at Cottonwood Slough on 23 May 1977 (JRS). The occurrence of this species at this time probably represents a migrant that wandered west of its usual range, although the species as "... observed by Mrs. Jefferson, fairly common in the town of Jasper" in 1947 (Jasper warden files).

HABITAT

Ruby-throated hummingbirds usually frequent "gardens, orchards: woodland clearings and edges... " (Godfrey 1966).

RUFOUS HUMMINGBIRD *Selasphorus rufus* **(B)** **RUHU**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: fairly common resident
Autumn: uncommon migrant
Winter: not recorded

The Rufous Hummingbird breeds from southern Alaska south to California and east to the Rocky Mountains (Godfrey 1966). In Alberta it occurs in the Rocky Mountains from Waterton Lakes north to Jasper (Salt and Salt 1976).

Spring migration is during late May and early June, peaking in late May. Earliest record is 17 May 1977 near Jasper townsite. Maximum recorded count is 10 on 28 May 1979 at Jasper townsite. Nesting has been recorded as early as 28 May 1974, in Banff townsite (Gordon 1975). The earliest recorded nest with unfledged young is 16 June 1976 near Jasper townsite (DJK). All four of the Rufous Hummingbird nests recorded in Banff and Jasper have been within 2 meters of the ground in spruce trees.

Autumn migration is in August. No concentrations of migrant Rufous Hummingbirds have been recorded. The latest record is 30 August 1977 in the upper North Saskatchewan River valley.

HABITAT

The Rufous Hummingbird occurs in open Douglas-fir forests, open treeline forests and forest edges, montane shrub meadows, and disturbed areas such as burns, avalanche slopes, and townsites. Small streams with shrubby margins are favoured. Although Rufous Hummingbirds frequent all ecoregions, especially during migration, they are most

frequent in the montane and lower subalpine ecoregions.

On 1736 call-count transects 32 Rufous Hummingbirds were recorded. Highest density indices were 32.99 in tall willow shrubbery (n=5), 39.58 in open aspen forest (n=4), 16.96 in open Douglas-fir forest (n=2), and 9.90 in mixed spruce/aspen forest (n=1). On avalanche slopes with krummholz and alder shrubbery, 7 Rufous Hummingbirds were recorded for a density index of 13.85.

CALLIOPE HUMMINGBIRD *Stellula calliope* **(b)** **CAHU**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: rare resident
Autumn: rare migrant
Winter: not recorded

The Calliope Hummingbird breeds in the mountains of western North America from central B.C. south to Colorado and Baja California (Godfrey 1966). In Alberta it breeds in the Rocky Mountains from Waterton Lakes to Jasper (Salt and Salt 1976).

Spring migration is during May. Earliest record is 20 May 1979 at Vermilion Lakes. No concentrations of migrant Calliope Hummingbirds have been recorded.

No nests have been recorded in Banff and Jasper and most records (12 of 14) are of individuals. An unusual concentration of 11 males was observed in a burn near North Saskatchewan River Crossing on 25 June 1976 (MED) but they were not recorded there subsequently on 2, 7, 8, 9 or 15 July. Salt and Salt (1976) state "nesting territories in Jasper were found within 0.25 mile of each other" but we have no other details.

Autumn migration is during August and no more than one bird has been recorded on any occasion. Latest record is 20 August 1977 in the upper Athabasca River valley.

HABITAT

Calliope Hummingbirds frequent avalanche slopes (4 of 16 records), burns (2), shrubby meadows (2) and open timberline forest (3), and other disturbed areas where flowers and berry shrubs are abundant. It occurs in the montane (7 records), lower subalpine (5), and upper subalpine (4) ecoregions.

Only 6 Calliope Hummingbirds were observed on 1736 call-count transects.

BELTED KINGFISHER *Megaceryle alcyon* **(B)** **BEKI**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: rare resident

The Belted Kingfisher breeds from Alaska and northern Canada south to Panama and Trinidad (Godfrey 1966). It occurs throughout Alberta (Salt and Salt 1976).

In Banff and Jasper, Belted Kingfishers are commonest in the Athabasca River, Bow River, lower Cascade River and lower North Saskatchewan River valleys.

Spring migration in Banff and Jasper is during late April and May. Earliest record is 23 April 1977 along the lower Athabasca River. Maximum count is five on 28 May 1952 at Whistler Creek (Jasper warden files).

The earliest nest recorded is 25 May 1979 on the lower North Saskatchewan River.

Autumn migration is during August and September. Maximum count is 3 on 6 August 1977 along the lower Athabasca River, and the latest record in Jasper is 9 October 1979 at Jasper townsite. In Banff Belted Kingfishers have been recorded much later, and individuals remain all winter. From 1 to 5 Belted Kingfishers have been recorded along the lower Bow River on most Christmas bird counts since 1974.

HABITAT

The Belted Kingfisher frequents large montane and lower subalpine rivers, streams and lakes that support fish populations and have exposed soil banks for nesting. They do not occur in the upper subalpine ecoregion. Open springs at Anthracite and the Cave and Basin Swamp are important areas for over-wintering kingfishers.

MANAGEMENT CONSIDERATIONS

Belted Kingfishers are too uncommon to be likely to affect the number of sports fish in the mountains. Belted Kingfisher were problem predators at the Banff and Jasper fish hatcheries but the numbers destroyed there were not recorded.

COMMON FLICKER *Colaptes auratus* **(B)** **COFL**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: common resident
Autumn: fairly common migrant
Winter: not recorded

The Common Flicker is represented in Banff and Jasper by two subspecies, the yellow-shafted flicker (*C.a. auratus*) and the red-shafted flicker (*C.a. cafer*). The Yellow-shafted Flicker breeds from northern Canada to the Gulf of Mexico, east of the Rocky Mountains. The Red-shafted Flicker breeds from Alaska to Mexico, west of the

Rockies. The ranges of the two subspecies overlap throughout Banff and Jasper and hybrids are commonly seen.

Spring migration is during April and early May, with the peak in late April. Earliest arrival is 7 March 1978 in the lower Bow River valley (McIvor and McIvor 1980). Flocks of Common Flickers have not been observed but a maximum count of 22 individuals and pairs was recorded on 12 April 1978 along 40 kilometers of highway 1A in Banff.

Nesting is during May to July. The earliest recorded nest is 10 May 1977 in the lower Bow River valley. The earliest nest with young is 31 May 1944 in the Blue Creek valley although young still in the nest have been recorded as late as 23 July (Cowan 1955). Since 1976 ten nests have been recorded.

Autumn migration is during August and September although individuals have been recorded as late as 17 October 1978 at Banff townsite. Maximum count is 16 on 16 September 1976 at the Valley of the Five Lakes in Jasper.

HABITAT

The Common Flicker frequents open forests and forest edges, especially on alluvial areas. Poplar and mixed forest are particularly favoured. Although this species has been recorded in the upper subalpine ecoregion (32 of 223 records since 1975), it is more common in the montane (117 records) and lower subalpine (74 records) ecoregions.

On 1736 call-count transects 85 Common Flickers were recorded. Highest density indices were recorded in tall montane willow thickets (5.23, n=5), open limber pine forest (14.12, n=3) and montane lodgepole pine savannah (3.49, n=6).

PILEATED WOODPECKER *Dryocopus pileatus* **(B)** **PIWO**

STATUS AND DISTRIBUTION

Spring: uncommon resident
Summer: uncommon resident
Autumn: rare resident
Winter: rare resident

The Pileated Woodpecker breeds throughout most of the forested parts of North America (Godfrey 1966), including all of Alberta except the prairies (Salt and Salt 1976). Although there is some winter dispersal, it is generally a year-round resident of its range.

In Banff and Jasper the Pileated Woodpecker is regularly present in the Athabasca River and Bow River valleys and occasionally elsewhere, but it is rarely seen. Most observations are during spring and summer; there are fewer than ten winter records on file.

Five nests have been found in the Bow River valley. A Pileated Woodpecker was observed excavating a nest hole near Muleshoe on 24 April 1943 (Clarke and Cowan 1945). Thirty three years later Pileated Woodpeckers were still nesting in the area: a nest with young was observed from 7 to 14 June 1976, with fledged young present on 26 June; and young were being fed at a nest on 1 June 1978 (McIvor and McIvor 1980).

HABITAT

Pileated Woodpeckers require mature and overmature forest with an abundance of dead and dying trees. Unlike other woodpeckers they rarely occur in burns and drowned

timber. Cowan (1955) feels that the species frequents "... Douglas-fir forests in preference to other habitats". Although mature Douglas-fir (2 of 37 records since 1975) and spruce forests (7 records), particularly on alluvial sites, are used by this species, it has also been observed in aspen (12 records) and mature pine (6 records) forest. All records are from the montane and lower subalpine ecoregions.

MANAGEMENT CONSIDERATIONS

The preservation of mature Douglas-fir forest, aspen forest and dense white spruce forests in the Athabasca River and Bow River valleys are essential to maintain this species. Removal of standing or fallen dead trees will greatly reduce the value of these habitats to the Pileated Woodpecker since they rely on dead and dying trees for feeding and nest sites.

LEWIS' WOODPECKER *Asyndesmus lewis* **(B)** **LEWO**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare resident
Autumn: not recorded
Winter: not recorded

The Lewis' Woodpecker breeds from southern B.C. south to New Mexico, mostly west of the Rocky Mountains (Godfrey 1966). In Alberta it nests "... irregularly and uncommonly in the Rocky Mountain regions of southwestern Alberta... " (Salt and Salt 1976).

Other than a single record in the Vermilion Pass Burn, all observations of Lewis' Woodpeckers in Banff and Jasper have been in the lower Bow River and lower Athabasca River valleys. There have been only five records in Banff, all from May and June, and none in Jasper since 1965. Lewis' Woodpeckers were formerly "... of occasional occurrence at Jasper" (Cowan 1955). A pair nested near Jasper Park Lodge in 1933 or 1934, and two pairs nested in the lower Athabasca River valley in 1946 (Cowan 1955). One of the latter two nests contained 5 fresh eggs on 19 June. Lewis' Woodpeckers are migratory. There are no autumn or winter records in Banff and Jasper.

HABITAT

Dry, open montane forests of Douglas-fir, white spruce and aspen with numerous dead snags are the favoured habitat of the Lewis' Woodpecker; there is one record from an extensive burn in the lower subalpine ecoregion.

YELLOW BELLIED SAPSUCKER *Sphyrapicus varius* **(B)** **YESA**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: rare migrant
Winter: not recorded

The Yellow Bellied Sapsucker breeds from Alaska and northern Canada south to the central U.S.A. (Godfrey 1966) and is found throughout Alberta except in the southern prairies (Salt and Salt 1976).

In Banff and Jasper it occurs mainly in the lower Bow River valley and much less commonly in other major valleys of the Front Ranges. There are three records from the Miette River valley and one each from the lower Cascade River, lower North Saskatchewan River and lower Red Deer River valleys.

Spring migration is during May although individuals have been seen in the lower Bow River valley as early as 25 April 1977. Yellow Bellied Sapsuckers do not migrate in flocks and the maximum recorded count is 1.

The species was "... reported nesting between 2nd and 3rd Vermilion Lakes, summer of 1974". (Gordon 1975). There are three other records, all nests with young. One was found near Duthill on 24 June 1975 (DJK), one on the Miette River flats on 2 July 1976 (DMI) and another on the Carrot Creek fan on 4 July 1979 (KAM).

Yellow Bellied Sapsuckers leave Banff and Jasper earlier than most autumn migrants. The latest record is 27 August 1976 at the Valley of Five Lakes in Jasper.

HABITAT

Yellow Bellied Sapsuckers are dependent on deciduous trees, particularly aspens, for feeding and nest sites. They occur primarily in aspen and mixed aspen/spruce forest on montane alluvial fans and floodplains. Of 21 records of this species since 1975, 14 were in deciduous forest and 19 were in alluvial areas. Only 1 was in the lower subalpine ecoregion.

HAIRY WOODPECKER *Dendrocopos villosus* **(B)** **HAWO**

STATUS AND DISTRIBUTION

Spring: uncommon resident
Summer: uncommon resident
Autumn: uncommon resident
Winter: uncommon resident

The Hairy Woodpecker breeds throughout the wooded regions of North America including all of Alberta (Salt and Salt 1976).

In Banff and Jasper this species is found mainly in the larger valleys of the Front Ranges, particularly the Bow River and Athabasca River valleys. It visits ornamental trees and feeders in Banff townsite and Jasper townsite in winter. Hairy Woodpeckers may

formerly have been more common than they are now. Cowan (1955) saw twenty during the field season of 1944; during the years 1975 to 1980 on this inventory only 58 were recorded in Banff and Jasper.

The Hairy Woodpecker is an early nester; a nest with eggs was found as early as 27 April 1978 in the lower Bow River valley, and hatched young were recorded as early as 17 May 1946 near Jasper townsite (Cowan 1955). Mating was observed on 31 May 1975 at Vermilion Lakes (McIvor and McIvor 1980).

From 1 to 11 Hairy Woodpeckers have been recorded on annual Christmas bird counts in Banff since 1974.

HABITAT

The Hairy Woodpecker frequents aspen (7 of 28 records) and spruce forest (9), wooded wetlands (8), and disturbed areas, in the montane (19 records) and lower subalpine (8 records) ecoregions.

DOWNY WOODPECKER *Dendrocopus villosus* **(B)** **DOWO**

STATUS AND DISTRIBUTION

Spring: uncommon resident
Summer: uncommon resident
Autumn: uncommon resident
Winter: uncommon resident

The Downy Woodpecker breeds throughout most of North America including all of Alberta (Salt and Salt 1976). Although it wanders in winter widely, it is not migratory.

In Banff and Jasper the Downy Woodpecker has been recorded only in the Athabasca River and Bow River valleys, and all winter records are from Banff townsite and Jasper townsite. It is less common than its larger relative, the Hairy Woodpecker.

There are only two nest records of Downy Woodpeckers, both from the lower Bow River valley in 1975. One was found on 9 July 1976 (JWW) and there were nestlings calling in a nest at Duthill on 24 June 1976 (DJK).

From 1 to 9 Downy Woodpeckers were observed on annual Christmas bird counts at Banff between 1974 and 1980.

HABITAT

The Downy Woodpecker frequents aspen woodland and tall deciduous shrubbery in the montane ecoregion (7 records of 14). In winter it is most frequently seen in shade trees and at feeders in Jasper townsite and Banff townsite (3 records). It has been recorded only once in the lower subalpine ecoregion.

BLACK-BACKED THREE-TOED WOODPECKER *Picoides arcticus* **(b?)** **BLWO**

STATUS AND DISTRIBUTION

Spring: very rare resident
Summer: very rare resident
Autumn: very rare resident
Winter: rare resident

The Black-backed Three-toed Woodpecker breeds across northern Canada and south in the Rockies to California and Wyoming (Godfrey 1966). In Alberta it occurs throughout the northern half of the province and the mountains but is not common anywhere (Salt and Salt 1976).

There are very few records of Black-backed Three-toed Woodpeckers in Banff and Jasper, with most being from the winter months. In 1941 three were seen during March and April at Brazeau Lake and Devona, and another in May 1946 at Talbot Lake (Cowan 1955). One seen on 9 July 1976 on the Palisades (GLH) is the only other record during the breeding season in Jasper. In Banff it has been recorded twice during the breeding season both times in the Vermilion Pass Burn. No nests or young have been reported.

Black-backed Three-toed Woodpeckers have been recorded seven times between September and December; once at Henry House (Cowan 1955), once in the lower North Saskatchewan River valley (MAS), and five times at Vermilion Lakes (McIvor and McIvor 1980). There are two late winter records from Banff (Gordon 1975).

HABITAT

The Black-backed Three-toed Woodpecker frequents "... coniferous woodlands and burned areas with standing dead trees" (Godfrey 1966). In Banff and Jasper it has been recorded in alluvial spruce forest, open shrub meadows with scattered spruce and fir, and along the edges of an extensive burn. Although it has been observed in both the upper subalpine and lower subalpine ecoregions, most records are from the montane.

Standing dead conifers are an important habitat requirement for this species.

NORTHERN THREE-TOED WOODPECKER *Picoides tridactylus* **(B)** **NOWO**

STATUS AND DISTRIBUTION

Spring: fairly common resident
Summer: uncommon resident
Autumn: uncommon resident
Winter: uncommon resident

The Northern Three-toed Woodpecker is a circumboreal species that breeds througout northern Canada, the northeastern USA, and the Rocky Mountains (Godfrey 1966). It occurs throughout the northern half of Alberta and the Rocky Mountains (Salt and Salt 1976).

In Banff and Jasper this species is more common than its quiet, retiring nature make it seem to be. Cowan (1955) considered it "... the most abundant and widespread woodpecker... " in Jasper, and in Banff it has also been described as being "... abundant

and widespread..." (Clarke and Cowan 1945). Only in March and April, however, when territorial drumming peaks, is this species readily observed; during the rest of the year it is quiet and inobstrusive.

There are four breeding records for Banff and Jasper. The earliest recorded nest was 2 June 1979 in the lower Brazeau River valley (KVT). Nests with young were observed on 14 July 1977 in the Spray River valley (MED) and on 25 July 1978 in the Howse River valley. Newly-fledged young were observed on 19 July 1939 at Bow Summit (Clarke and Cowan 1945).

Northern Three-toed Woodpeckers are more abundant in the valleys of the Front Ranges than deeper in the mountains but are found in most parts of both Banff and Jasper.

HABITAT

The Northern Three-toed Woodpecker prefers mature spruce/fir, spruce/pine, white spruce, and lodgepole pine forests with an abundance of standing dead conifers. They are most common in the lower subalpine ecoregion (77 of 98 records since 1975), but occur in the montane (14 records) and upper subalpine (7 records) ecoregions too.

On 1736 call-count transects, 36 Northern Three-toed Woodpeckers were recorded. Highest density indices were in dry montane closed white spruce forest (11.46, n=3), moist lower subalpine closed spruce/fir forest with a herbaceous understory (3.40, n=4), and moist lodgepole pine/spruce forest (2.37, n=8).

EASTERN KINGBIRD *Tyrannus tyrannus* **(B)** **EAKI**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: fairly common resident
Autumn: uncommon migrant
Winter: not recorded

The Eastern Kingbird breeds across North America from southern Mackenzie and southern Canada to southern parts of the United States (Godfrey 1966). It occurs throughout Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in mid and late May. The earliest record is 9 May 1978 in the lower Bow River valley. Usually only a few are seen at any one time, but a maximum of 25 were counted on 17 May 1977 at Vermilion Lakes. This species is the most common spring flycatcher in the wetlands near Banff, but it is less common in Jasper.

In the summer it occurs only in the lower valleys. It is most common in the lower and middle Bow River and lower Athabasca River watersheds, and has also been recorded in the lower North Saskatchewan River, lower Brazeau River and Miette River watersheds. It occurs regularly at Vermilion Lakes and Talbot Lake. There is one nest record for Banff, a nest found on 29 June 1979 at Vermilion Lakes; on 27 July there were two young in the nest (McIvor and McIvor 1980). There are no nest records for Jasper.

Autumn migration occurs in August. The latest record is 8 September 1977 at Vermilion Lakes; the maximum count of nine was also recorded there on 18 August 1977. This species is the most common autumn flycatcher, particularly in Banff.

Prior to the 1940's, this species was apparently very scarce in Jasper (Cowan 1955).

HABITAT

The Eastern Kingbird occurs in open places in the montane ecoregion. It inhabits areas of deciduous shrubbery, often where there are standing drowned trees, adjacent to wetlands and lakes.

During the breeding season the highest densities of Eastern Kingbirds are in willow/horsetail (S7) (DI=12.70) and dwarf birch-shrubby cinquefoil/needlerush (S3) (DI=12.03) shrublands. It occurs at a lower density (DI=4.08) in water sedge-beaked sedge (H11) meadows with scattered willows.

WESTERN KINGBIRD *Tyrannus verticalis* **WEKI**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Western Kingbird breeds in west-central North America from southern British Columbia south to northwestern Mexico (Godfrey 1966). It breeds in southeast Alberta, west to Calgary (Salt and Salt 1976).

There are no Banff records of this species. For Jasper, there are three records: one on 25 May 1979 at Ranger Creek (KVT), 1 on 13 June 1971 at Willow Creek (Carbyn 1972a), and 1 on 29 June 1930 in the lower Athabasca River valley (Cowan 1955).

HABITAT

The Western Kingbird inhabits "open situations such as prairies but in the vicinity of at least one or two trees,... and in the mountains open areas among scattered trees" (Godfrey 1966). The only common factor in the three Jasper records of this species is that they were in open areas in the montane ecoregion.

EASTERN PHOEBE *Sayornis phoebe* **EAPH**

STATUS AND DISTRIBUTION

Spring: rare visitor
Summer: very rare visitor
Autumn: very rare visitor
Winter: not recorded

The Eastern Phoebe breeds in central North America east of the Rocky Mountains (Godfrey 1966). It breeds in most parts of Alberta, excluding the Rockies, and very locally in the foothills and southern prairies (Salt and Salt 1976).

There are four Banff records, all from Vermilion Lakes and Banff townsite. The earliest record of one on 26 April 1976 (McIvor and McIvor 1980) and the latest record of one on 5 August 1975 (G. Wapple, pers. comm.) occurred here. Also, one was seen on 5 June 1966 (Gordon 1975), and one on 16 July 1975 (Bow Valley Naturalists 1978). Gordon (1975) states that it "occurs around Vermilion Lakes and Johnson's Lake" but gives no dates.

There is only one recent record for Jasper: an Eastern Phoebe was seen on 6-7 May 1980 at Isaac Creek (RLM). However, there are several old records from the lower Athabasca River valley: on 11 May 1944 three pairs were seen at Miette, a pair was seen there again in 1946, at Devona one pair was seen on 16 May 1944 and one bird on 13 August 1943 (Cowan, 1955); on 10 June 1946, two were seen at Disaster Point (Banfield 1946).

HABITAT

The Eastern Phoebe inhabits open woods and the edges of clearings, and "often the vicinity of streams and lakes where rocky walls or bridges provide nesting places, and trees or shrubbery furnish foraging places" (Godfrey 1966). In Banff and Jasper it has been observed at woodland edges, adjacent to lakes or in alluvial areas, in the montane and lower subalpine ecoregions.

SAY'S PHOEBE *Sayornis saya* **SAPH**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: rare visitor
Autumn: rare migrant
Winter: not recorded

Say's Phoebe breeds in western North America from Alaska south to northern Mexico (Godfrey 1966). In Alberta it nests most commonly in the southeastern prairies, but also nests in the parklands and foothills (Salt and Salt 1976).

There are two Jasper spring records: one on 5 May 1972 at Willow Creek (Carbyn 1972a), and one in May 1945 at the lower Athabasca River (Cowan 1955). There are seven spring records for Banff, all from the Banff townsite vicinity. On all occasions only one was recorded, the earliest being on 31 March 1976 (McIvor and McIvor 1980); all other observations were from 5 to 15 May.

Summer records include: individuals on 21 June and 9 July 1918, 29 June 1930, and 12 June 1946 in the lower and middle Athabasca River valleys (Cowan 1955); two on 10 June 1946 in the lower Athabasca River valley (JNP records); and one on 21 June 1977 in the lower Spray River valley (KAM).

Autumn records include individuals on 22 August 1978 in the Cavell meadows (KVT), 29 August 1978 in the lower Cascade River valley (MED), and 29 August 1979 (DJH) and 8 September 1943 (Cowan 1955) at Jasper townsite.

HABITAT

Say's Phoebe inhabits "open, usually dry, places where bushes, fences, buildings, or even low rocks and earth hummocks provide look-out perches" (Godfrey 1966). In Banff and Jasper it has been observed in open areas from the montane to upper subalpine ecoregions.

YELLOW-BELLIED FLYCATCHER *Empidonax flaviventris* **YBFL**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

This species breeds in North America east of the Rockies from southwest Mackenzie and northeast British Columbia to Newfoundland and south to the central prairie provinces, North Dakota and New York (Godfrey 1966). It breeds in northern Alberta south to Grande Prairie (Salt and Salt 1976).

There are no Jasper records, and only one Banff record of this species. One bird was heard on 20 June 1978 in the Healy Creek backswamp (D. Brunton, pers. comm.).

HABITAT

The Yellow-bellied Flycatcher inhabits "shady, moss-floored thickets and woodland; alder-willow shrubbery often mixed with conifers; bogs; (and) wood streams" (Godfrey 1966). The Banff record is from a montane wetland complex bordered by white spruce forest.

WILLOW FLYCATCHER *Empidonax alnorum* **(b)** **WIFL**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: fairly common resident
Autumn: uncommon migrant
Winter: not recorded

The Willow Flycatcher breeds across North America from southern Canada to the southern United States (Salt and Salt 1976). It has only recently been separated as a species from the Alder Flycatcher, so breeding ranges of both have not yet been outlined accurately. In Alberta to date the Willow Flycatcher has been "recorded in the summer only in the Rockies and their foothills from near Banff north to Jasper" (Salt and Salt 1976).

In the spring, there is only one Banff record, two seen on 16 May 1977 along the lower Bow River (MED). There are also a few late May sightings of unidentified *Empidonax*, some of which may be this species. When not vocalizing, birds of this genus are inseparable in the field.

In the summer, it is one of the more common flycatchers in Banff, and is far more common here than in Jasper. It is encountered most frequently in the lower and middle Bow River valleys, but has also been recorded in Banff in the upper Spray River, lower Cascade River, and Panther River watersheds. In Jasper, one or two have been recorded in several southern valleys of the park and at Jasper townsite. There are no nest records.

In the autumn it departs early, with few remaining after early August. The latest record is an individual on 12 August 1975 at Vermilion Lakes. The maximum count of 13 was on 2 August 1977 near Banff townsite. It is usually encountered singly or in small groups of up to 5.

HABITAT

The Willow Flycatcher is most common in the montane ecoregion, but also occurs regularly in the lower subalpine ecoregion. It inhabits birch and willow thickets of alluvial wetlands and, to a lesser extent, marshy lake shores.

During the breeding season this species occurs in dwarf birch–shrubby cinquefoil/needlerush (S3) wetlands (DI=15.79) where it is more abundant than the closely-related Alder Flycatcher (DI=1.61). However, Willow Flycatchers do not breed in as wide a variety of habitats as Alder Flycatchers, having been recorded on transects in no other habitats.

ALDER FLYCATCHER *Empidonax traillii* (b) **ALFL**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: uncommon resident
Autumn: rare migrant
Winter: not recorded

The Alder Flycatcher breeds across North America from Alaska and the Yukon east to Newfoundland, and south to central British Columbia and the boreal forest of eastern Canada and the United States (Salt and Salt 1976). It "breeds in most of southern Alberta north at least to Athabasca and probably farther" (ibid). The breeding range is not yet outlined accurately because it has only recently been separated as a species from the Willow Flycatcher.

Spring migration in Banff and Jasper occurs in late May and early June; most likely arrive back in early June. The earliest record and maximum count of three was on 19 May 1978 in the lower Athabasca River valley.

In the summer it is more common in Jasper than in Banff, and is most numerous throughout the Athabasca River valley. There are also records from the lower and middle Bow River and the Miette River; it likely occurs elsewhere in Banff and Jasper as well. Cowan (1955) found "Traill's Flycatcher", probably most of which were this species, to be "fairly common... . along the Athabasca valley and up the Snake Indian as far as Willow Creek." There are no nest records.

Autumn migration is early, with few birds remaining after July. The latest record is an individual on 8 August 1977 near Banff townsite. No more than one or two were seen on any occasion.

HABITAT

The Alder Flycatcher occurs primarily in the montane ecoregion, but is also found regularly in the lower subalpine ecoregion. It inhabits willow and birch thickets on alluvial wetlands and along streams, lakeshores and forest margins.

During the breeding season the highest densities of Alder Flycatchers are in willow/horsetail (S7) thickets (DI=3.40) and subalpine fir-willow (S2) avalanche slopes (DI=2.04). It occurs at lower densities in dwarf birch-shrubby cinquefoil/needlerush (S3) (DI=1.61) and water sedge-beaked sedge (H11) wetlands. Nowhere is it as abundant as the Willow Flycatcher which, however, is restricted to a narrower area of habitat and geographical range in Banff and Jasper.

LEAST FLYCATCHER *Empidonax minimus* **(B)** **LEFL**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: fairly common resident
Autumn: uncommon migrant
Winter: not recorded

The Least Flycatcher breeds across North America from the southern Yukon and southern Canada (excluding most of western British Columbia) south to Montana and North Carolina (Godfrey 1966). It breeds throughout Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs primarily in late May and early June. The earliest record is four birds on 9 May 1978 in the lower Bow River valley. The maximum count is 19 on 4 June 1976 along the middle Athabasca River. It is usually encountered singly or in small groups of up to five.

In the summer, it is considerably more common in the lower Bow River, Miette River and Athabasca River valleys than elsewhere in the parks. There are recent records from several other valleys, primarily in Banff. Cowan (1955) heard "many" along the lower Snake Indian River on 1-3 June 1944. There is one nest record: in Banff on June 1966 a nest with 3 eggs was found by Aileen Harmon. This is one of the more common flycatcher species in Banff and Jasper.

Autumn migration occurs in August. The latest record is two birds on 9 September 1977 near Banff townsite. No more than one or two birds were recorded on any occasion.

HABITAT

The Least Flycatcher is most common in the montane ecoregion, but also occurs regularly in the lower subalpine ecoregion. It inhabits deciduous habitats.

During the breeding season the highest densities of Least Flycatchers are in willow-green alder/bluebell (S6) (DI=24.62) and willow/horsetail (S7) (DI=10.94) thickets, and aspen/hairy wild rye-peavine (C16) forest (DI=6.45). The species also occurs, at lower densities, in other deciduous and mixed forests and in shrub-dominated montane wetlands.

HAMMOND'S FLYCATCHER *Empidonax hammondii* **(b)** **HAFL**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: rare migrant
Winter: not recorded

Hammond's Flycatcher breeds in western North America from Alaska to California, and east to the Rockies (Godfrey 1966). In Alberta, it is restricted to the Rocky Mountains from Jasper to Waterton Lakes (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in mid and late May. The earliest record on 17 May 1977, and the maximum count of 12 birds on 19 May 1978 were along the middle Athabasca River. It is usually encountered singly or in pairs.

In the summer it appears to be more common in Jasper and northern Banff than in southern Banff. The relatively few records south of the lower North Saskatchewan River were in the Panther River and Bow River valleys. There are no recent records north of the Miette and lower Athabasca Rivers, but Cowan (1955) considered the species to be "fairly common" along the lower Snake Indian River in 1943 and 1944. Its distribution and abundance are not easy to discern because of difficulties in separating this species from the Dusky Flycatcher. Of the two, Hammond's Flycatcher appears to be the more common flycatcher in the summer. There are no nest records.

Autumn migration occurs in August. The latest record is an individaul on 24 August 1977 near Jasper townsite. In the autumn, this flycatcher is difficult to distinguish from other *Empidonax* species, most of which have usually left by the end of August.

HABITAT

Hammond's Flycatcher occurs in open and closed forests of the montane and lower subalpine ecoregions, and occasionally in the upper subalpine ecoregion. In contrast to the Dusky Flycatcher, which prefers deciduous scrub, it is primarily a bird of mature coniferous forests (Salt and Salt 1976). It also inhabits mixed forests and forest edges.

During the breeding season the highest densities of this species are in Douglas-fir forest (DI=3.37), open white spruce stands on dry slopes (white spruce/juniper/bearberry (O17) (DI=3.50), and shrubby cinquefoil/bearberry-northern bedstraw (L1) (DI=3.68). It occurs at lower densities in dry lodgepole pine forests but was not recorded on transects in Engelmann spruce-subalpine fir or lodgepole pine-spruce forests.

DUSKY FLYCATCHER *Empidonax oberholseri* **(B)** **DUFL**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

The Dusky Flycatcher breeds in western North America from the Yukon to California, primarily from the Rockies westward (Godfrey 1966). In Alberta it is restricted to the Rocky Mountains and their foothills from Jasper to Waterton Lakes, and the Cypress Hills (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in late May. The earliest record is one seen on 13 May 1952 at Pyramid Lake in Jasper (Banfield 1954b).

In the summer it appears to be more common in Banff than Jasper, the reverse pattern of that for the very similar and often indistinguishable Hammond's Flycatcher. It was recorded throughout Banff and, in Jasper, as far north as the middle Athabasca River and the Southesk River.

There are two Banff nest records, the earlier being a nest with 4 young (about five days old) found on 3 July 1978 in the lower North Saskatchewan River valley, (MED). On the same date, 3 fledged young were seen with a female near the Howse River (MJD). There is an old nest record for Jasper, a nest with 4 young found on 25 July 1917 in

the middle Athabasca River valley (Cowan 1955).

Autumn migration likely occurs in August, The latest record is an individual on 12 August 1977 at Vermilion Lakes. It is difficult to distinguish in autumn from other *Empidonax* flycatchers, all of which have usually left by the end of August.

Cowan found "small flycatchers, presumably of this species" to be "fairly common" in the Athabasca River valley in 1944 and 1946. From 1946 to 1952 Banfield recorded 11 Dusky Flycatchers in the lower and middle Athabasca River valleys (Jasper warden files). Lack of recent records here possibly reflects the difficulty in distinguishing this species from Hammond's Flycatcher.

HABITAT

The Dusky Flycatcher occurs in the montane and lower subalpine ecoregions. Unlike Hammond's Flycatcher, which prefers coniferous forests, it primarily inhabits deciduous habitats, particularly low scrubby growth.

The highest densities of this species during the breeding season are in open aspen forest (DI=41.67) and aspen/hairy wild rye-showy aster (C22) forest (DI=20.00). It occurs at lower densities in other deciduous forests and on subalpine fir-willow (S2) avalanche slopes.

WESTERN FLYCATCHER *Empidonax difficilis* **(B)** **WEFL**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: rare resident
Autumn: very rare migrant
Winter: not recorded

The Western Flycatcher breeds in western North America almost solely west of the divide, from Alaska to Honduras (Godfrey 1966). In Alberta it is restricted to the southwestern mountains and foothills (Salt and Salt 1976).

For Banff, there is one spring record of this species, a male heard singing on 19 May 1977 along the lower Bow River (MED).

In the summer, small numbers were recorded in several valleys of both parks, including the lower and middle Bow River, lower Spray River, Alexandra River, Southesk River, lower Athabasca River, Miette River, Isaac Creek and lower Rocky River.

There is one nest record: On 16 July 1978 at Johnston Creek in Banff a nest with 3 young was found in a cave (MJD). Also, on 11 August 1979 an adult was seen carrying food, presumably to young, near Talbot Lake (DJH).

There are two autumn records, the above sighting on 11 August 1979, and one on 16 August 1973 near the Mistaya River (Gordon 1975).

There are no records of this species in either of the parks previous to the 1970's.

HABITAT

The Western Flycatcher occurs primarily in the montane and lower subalpine ecoregions, but is occasionally encountered in the upper subalpine. It inhabits open forests, most often coniferous, especially near streams or seepages.

WESTERN WOOD PEEWEE *Contopus sordidulus* **(b)** **WEPE**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

The Western Wood Peewee breeds in the western half of North America from Alaska to Panama (Godfrey 1966). It nests throughout Alberta (Salt and Salt 1976).

In Banff and Jasper spring migration occurs in mid and late May. The earliest record on 6 May 1977 and the maximum count of 19 birds on 28 May 1977 were in the lower Athabasca River valley. It is usually encountered singly or in small flocks of up to five birds. This is the most common spring flycatcher in Jasper, although it is less common in Banff.

In the summer it is fairly widely distributed throughout both parks. It is most common throughout the Bow, Athabasca and Miette valleys, but has been recorded in other watersheds; however, there are no records for Jasper north of the Miette and lower Athabasca Rivers. There are no nest records.

Autumn migration is in August. The latest record is an individual seen on 21 August 1977 along the upper Athabasca River. Only one or two were seen on any one occasion.

HABITAT

The Western Wood Peewee occurs primarily in the montane ecoregion, but is occasionaly encountered in the lower subalpine ecoregion. It is a woodland bird, inhabiting deciduous, mixed, and open coniferous forest and forest edges often adjacent to wetlands.

The highest densities of this species during the breeding season are in deciduous forest (DI=1.27), especially aspen/hairy wild rye-peavine (C16) (DI=1.40), Douglas fir/juniper/bearberry (05) forest (DI=1.68) and willow/horsetail (S7) thickets (DI=1.31). Lower densities occur in other types of open coniferous forest and on shrubby avalanche slopes.

OLIVE-SIDED FLYCATCHER *Nuttallornis borealis* **(B)** **OLFL**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: uncommon resident
Autumn: rare migrant
Winter: not recorded

The Olive-sided Flycatcher breeds in wooded regions across North America from near treeline to the southern United States (Godfrey 1966). It breeds in north and central Alberta, and in the west as far south as Waterton Lakes (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in late May and early June. The earliest record is 14 May 1974 at Vermilion Lakes (Gordon 1975).

In the summer, although not common at any location, it occurs throughout both parks and thus is, overall, one of the most common flycatchers. There are no nest records. "Four young, just out of the nest... ." were seen at Cavell Lake in Jasper on 1 July 1944 (Cowan 1955).

Autumn migration occurs in August. The latest record is one on 3 September 1965 at Banff (Sadler and Myres 1976).

HABITAT

The Olive-sided Flycatcher occurs most commonly in the lower subalpine ecoregion, but is also frequently found in the montane and upper subalpine ecoregions. It inhabits coniferous forests, mixed coniferous/deciduous forests, burntlands and, near timberline, fir krummholz areas.

During the breeding season the highest densities of Olive-sided Flycatchers are in subalpine fir-willow (S2) avalanche slopes (DI=2.79), mixed aspen-lodgepole pine forest (DI=2.33) and Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14) open forest (DI=1.27). Lower densities occur in several other coniferous forest types and shrubby habitats.

HORNED LARK *Eremophila alpestris* **(B)** **HOLA**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: common resident
Autumn: uncommon migrant
Winter: rare visitor

The Horned Lark breeds throughout most of the Northern Hemisphere; in North America it is absent or extremely local in forested regions (Godfrey 1966). It breeds in central and southern Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in late April and May. The earliest record is one on 17 March 1979 at Vermilion Lakes (McIvor and McIvor 1980). The next earliest record is one on 22 April 1978 near Banff townsite. Although usually seen in small groups of up to 10 birds, 30 were seen on 25 May 1944 at Willow Creek (Cowan

1955).

In the summer it ocurs throughout both parks, but is more common in Jasper than in Banff. Particularly good locations appear to be in the Sunwapta River and Rocky River watersheds. There is one nest record for each park. In Banff, a nest with 4 young was found on 14 July 1967 at Nigel Pass (Staender, BNP warden cards). In Jasper, a nest with 2 eggs was found on 10 June 1977 at Wilcox Pass (JDS).

Autumn migration is in September and October, peaking in mid and late September. An unusually late flock of eight was seen on 27 November 1978 in the lower Athabasca River valley (JLK); otherwise the latest record is 20 October 1968 in the lower Bow River valley (Gordon 1975). Flocks of up to twenty are usual; the maximum count was a flock of 40 seen on 19 September 1977 in the upper Bow River watershed.

There are two winter records, one seen on 16 December and 14 January 1979 in the lower Athabasca River valley (KVT). The occasional migrant may lag when there is little snow cover; the nearest wintering grounds are only as far away as southeast Alberta.

HABITAT

The Horned Lark almost exclusively inhabits well-drained alpine tundra; occasionally it is seen elsewhere in the alpine and subalpine ecoregions. On migration it is usually seen in low-elevation short-grass areas, including highway right-of-ways.

By far the highest density of Horned Larks during the breeding season is in mountain avens-snow willow-moss campion (H1) tundra (DI=24.24). By contrast, heather-everlasting (L5) meadows sustain only 10% as many Horned Larks (DI=2.60).

VIOLET-GREEN SWALLOW *Tachycineta thalassina* **(B)** **VISW**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

The Violet-green Swallow breeds in mountain regions of western North America from Alaska to southern Mexico (Godfrey 1966). It breeds in southwest Alberta in the Rocky Mountains (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs primarily in early and mid May. The earliest record is 4 April 1966 at Banff townsite (Gordon 1975); the next earliest is two on 22 April 1977 at Banff townsite. Flocks of more than 15 birds are unusual. The maximum count is 40 on 6 May 1979 at Talbot Lake (KVT).

In the summer it appears to have a fairly restricted distribution. In Banff, it occurs mainly in the vicinity of Vermilion Lakes and Banff townsite, but has also been recorded along the middle Bow River and the lower Cascade River. In Jasper, it occurs along the Athabasca River particularly in the vicinity of Jasper townsite and nearby Patricia Lake, and has also been recorded at the lower Brazeau River. It likely occurs elsewhere in both parks, particularly where there are buildings. There are two nest records for Jasper: both nests were found in the same drowned spruce on 25 June 1944 in the lower Athabasca River valley (Cowan 1955). In Banff, the Violet-green Swallow nests at the Banff Springs Hotel; although the number of nests is unknown, over 50 birds were seen here on 17-19 June 1977 (A. Grey, pers. comm.). The only other nest record is a nest found

on 17 June 1977 in the lower Bow River valley (MED).

Autumn migration occurs in late July and August. The latest record is one on 17 August 1978 at Talbot Lake. Only one or two were recorded on any one occasion.

This swallow appears to have been formerly more common. Clarke and Cowan (1945) considered it "common" in summer at Banff and Lake Louise. Cowan (1955) in 1943 and 1944 found it "fairly common along the Athabasca Valley and up the Snake Indian River".

HABITAT

The Violet-green Swallow occurs primarily in the montane ecoregion, but is occasionally seen in the lower subalpine ecoregion. It prefers townsites, beaverponds and lakeshores, all of which it finds in the vicinity of Banff and Jasper townsites where it is most common.

It nests readily in birdhouses or under eaves of buildings as well as in tree holes and cliff crevices.

TREE SWALLOW *Iridoprocne bicolor* **(B)** **TRSW**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: common resident
Autumn: uncommon migrant
Winter: not recorded

The Tree Swallow breeds across North America from near treeline in Canada and Alaska south to southern parts of the United States (Godfrey 1966). It nests throughout Alberta, although less commonly in the southeast prairies (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in late April and May usually peaking in mid to late May; in years of an early spring, large numbers have been recorded in early May. The earliest record is 5 pairs on 17 April 1943 near Jasper townsite (Cowan 1955). Although flocks are usually of fewer than 50 birds, the maximum counts included as many as 150 on 20 May 1979 at Talbot Lake, and 105 on 16 May 1978 at Vermilion Lakes.

In the summer it is most common in the lower Bow River valley, but has been recorded throughout both parks. The earliest nest record is 28 May 1944 at Snake Indian Lake (Cowan 1955). Tree and Cliff Swallows are the most common swallow species.

Autumn migration occurs in late July and August; most have usually left by the end of July. The latest record is one on 8 September at Vermilion Lakes. Less than five were seen on any one occasion.

There are very few records of the Tree Swallow in Banff prior to the 1940's; Clarke and Cowan (1945) had no record of it until 1943. However, in Jasper it was "an abundant summer resident" as long ago as the turn of the century (Cowan 1955).

HABITAT

The Tree Swallow occurs in the montane and, to a lesser extent, the lower subalpine ecoregion. Its natural habitat is mature woodlands close to water, usually beaver ponds or lake edge, where it nests in old woodpecker holes. It also inhabits townsites and will nest in nest boxes.

BANK SWALLOW *Riparia riparia* **(B)** **BKSW**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: uncommon resident
Autumn: fairly common migrant
Winter: not recorded

The Bank Swallow breeds across temperate North America and Eurasia. In North America it breeds from about treeline to the southern United States (Godfrey 1966). It nests throughout Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in May and early June, peaking in late May. The earliest record of one on 2 May 1977, and the maximum recent count of 65 birds on 30 May 1977 occurred at Vermilion Lakes. On 2 June 1943 a flock of 302 was seen at Banff townsite (Clarke and Cowan 1945). Large flocks are not unusual.

In the summer, flocks of 10 to 40 birds have been recorded in the valleys of the lower Bow River, lower Cascade River, and the upper Athabasca River. The occasional individual or pair was seen along the middle Bow River, Clearwater River, lower North Saskatchewan River and the lower and middle Athabasca River. There is little information on colony sizes or locations. There are no nest records for Banff. In Jasper a nesting colony of 12–15 pairs was found at Talbot Lake in early June 1944 and a colony was found near Devona on 4 June 1946 (Cowan 1955); there are few recent nest records.

Autumn migration occurs in late July and in August. The latest record is four seen on 23 August 1978 at Talbot Lake. The maximum count is 40 on 28 July 1975 along the lower Bow River.

HABITAT

The Bank Swallow occurs in the montane and, to a lesser extent, the lower subalpine ecoregions. It nests colonially in steep banks of rivers, lakes and open areas where it can excavate its nest tunnel close to the top of the bank.

MANAGEMENT CONSIDERATIONS

Bank Swallows will excavate tunnels for their breeding colonies in roadside and railway cutbanks, including those that are as little as 2 m high. Disturbance to colonies should be minimized in June and early July when nesting occurs. Since there are few recent records of colonies, any found should be protected.

ROUGH-WINGED SWALLOW *Stelgidopteryx rupicollis* **(B)** **ROSW**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

The Rough-winged Swallow breeds locally across North and South America from southern Canada to Peru and Argentina (Godfrey 1966). It breeds in southern Alberta, north to Jasper in the Rockies (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in May, peaking in early and mid May. The earliest record is two on 2 May 1978 at Talbot Lake. The maximum count of 100 was on 5 May 1977 at Vermilion Lakes. Flocks of about 25 are not uncommon.

In the summer Rough-winged Swallows are more common in Banff than Jasper; flocks of 5 to 30 were recorded only along the lower and middle Bow River, Mistaya River, and lower North Saskatchewan River. Banfield recorded 10 along the lower Athabasca River in June 1946 (Jasper warden cards). The occasional bird was seen along the Howse, lower Brazeau and Miette Rivers, and near Jasper townsite. There is only one recent nest record for each of Banff and Jasper: a nest found on 22 June 1977 along the lower Athabasca River (DJK) and a nest along the middle Bow valley on 26 June 1975 (JWW).

Autumn migration is from late July to mid August. The latest record is 19 August 1977 at Banff townsite. The maximum count is 15 on 3 August 1977 at Vermilion Lakes.

Apparently this swallow was formerly more common in Jasper. Cowan (1955) found two colonies of 5 or 6 pairs in roadside cutbanks along the lower Athabasca River in June 1944, one at Talbot Lake and the other at the sulfur springs near Snaring, on 15 June incubation was in progress. On 31 May 1946 Cowan (1955) observed nest building in a cutbank near Decoigne. In 1939 a colony was nesting in the river bank at North Saskatchewan River Crossing (Clarke and Cowan 1945).

HABITAT

The Rough-winged Swallow occurs around rivers, lakes and open areas in the montane and, to a lesser extent, the lower subalpine ecoregions. It occurs where there are suitable banks for it to excavate nest chambers. Unlike the highly colonial Bank Swallow, usually only 1-3 pairs occupy a site.

MANAGEMENT CONSIDERATIONS

The Rough-winged Swallow often uses roadside cutbanks for nesting, usually excavating its nest close under the upper rim.

BARN SWALLOW *Hirundo rustica* **(B)** **BNSW**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: fairly common resident
Autumn: fairly common migrant
Winter: not recorded

The Barn Swallow breeds across North America and Eurasia from near treeline south, in North America, to central Mexico (Godfrey 1966). It nests throughout Alberta, although less commonly in the mountains and far north (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in May, peaking in late May. The earliest record is one on 2 May 1978 in the lower Athabasca River valley. The maximum count is 64 on 30 May 1977 at Vermilion Lakes. It is usually seen in flocks of less than 15.

In the summer it occurs throughout both parks, and is often found near man-made structures. There are numerous nest records for both parks spanning June and July; the earliest with eggs was found on 3 June 1978 along the middle Maligne River (KVT). A nest that was being built on 1 June 1979 at Bankhead did not have its first egg until 20 June and had 5 eggs on 24 June (GLH). Although there are undoubtedly earlier broods, the earliest record is 13 July 1978 (1 egg and 3 young) in the lower Cascade River valley (GLH).

Autumn migration lasts from early August to mid September, peaking in mid August. The latest record is one on 5 October 1978 at Banff townsite (P. Pratt, pers. comm.). The maximum count is 30 birds on 9 August 1977 at Vermilion Lakes.

Macoun and Spreadborough found the Barn Swallow to be "common" in Banff and Jasper at the turn of the century; however, none were reported in the mid 1940's (Clarke and Cowan 1945, Cowan 1955).

HABITAT

The Barn Swallow occurs primarily in the montane and lower subalpine ecoregions, but is also found in the upper subalpine ecoregion. On migration it is occasionally seen in the alpine. It favors areas near rivers or lakes, especially where there are man-made structures such as bridges, culverts, or buildings on which to build its nest. It also nests in crevices on cliffs and in hollow trees.

CLIFF SWALLOW *Petrochelidon pyrrhonota* **(B)** **CLSW**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: common resident
Autumn: common migrant
Winter: not recorded

The Cliff Swallow breeds across North America from treeline south to southern Mexico (Godfrey 1966). It nests locally throughout Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in May, peaking in late May. The earliest record in one on 6 April 1971 at Jasper townsite (Young, JNP records); the next earliest record is six on 2 May 1978 at Talbot Lake. The maximum count was about 200 on 25 May 1977 at Vermilion Lakes. Large flocks of over 100 are not uncommon. This is the most common swallow in the spring.

In the summer, large colonies are more common in Banff than in Jasper. In Banff, colonies of 50 to 100 birds have been recorded nesting along the lower and middle Bow River (including Banff townsite), Baker Creek, and the Clearwater and Siffleur Rivers. Flocks of this size have also been seen along the lower Cascade River and Mistaya River. Smaller flocks of up to 15 have been seen along the upper Bow River and Pipestone River. In Jasper it is less widespread. Up to 150 birds were recorded at Maligne Lake, with at least some of these nesting on the bridge at the outlet (5 June 1978, DJH). However, only up to 4 birds were seen elsewhere in Jasper, including the Astoria River, middle Snake Indian River and Jasper townsite. Actual counts of nests include 50 found on 10 August 1979 along the Clearwater River, 35 on 21 June 1978 along the Siffleur River (MJD), and 15 on 6 June 1975 under the mile 5 bridge in the middle Bow River valley (JWW). There are no records for the earliest active nest. This swallow, and the Tree Swallow, are the most common swallows in Banff and Jasper.

Autumn migration occurs in late July and August, peaking in early August. The latest record is 3 September 1912 in Banff (Clarke and Cowan 1945). Maximum count is 95 on 10 August 1943 at Blue Creek (Cowan 1955). Small flocks are usually seen, but flocks may vary from 10 to 100 birds.

HABITAT

The Cliff Swallow occurs from the montane to the upper subalpine ecoregion, usually near rivers or lakes. It builds its nest of mud pellets on cliffs, steep banks, and man-made structures such as buildings and bridges.

There are two colonies in Banff in the alpine ecoregion: 50 nests overlooking Redoubt Lake at 2425 meters elevation (MED) and 50 nests overlooking Devon Lakes at 1175 meters elevation (HFC). No other swallows nest in the alpine and these unique colonies are worthy of special protection.

GRAY JAY *Perisoreus canadensis* **(B)** **GRJA**

STATUS AND DISTRIBUTION

Spring: common resident
Summer: very common resident
Autumn: common resident
Winter: common resident

The Gray Jay breeds across North America from near treeline south to south-central parts of the United States in the west, and northern parts in the east (Godfrey 1966). It occurs in mountainous and northern areas of Alberta to the edge of the parklands (Salt and Salt 1976).

In Banff and Jasper it is a permanent resident that is ubiquitous throughout both parks. Most birds remain in the winter, although some may wander south and east. It is not a social bird, and sightings of groups of more than five are unusual except in areas of human disturbance where larger groups may congregate. The largest number recorded was 68 birds on 3 June 1977 along the Bow Summit migration survey route in the upper

Bow River valley. Most groups in the spring and summer are family groups.

There are no Jasper nest records, and only one for Banff; the dearth of records is partly due to the Gray Jay's habit of nesting in late winter, usually March. In Banff townsite, a pair was first observed building a nest on 6 March 1979; on 19 March an adult was on the nest, and when the nest was checked on 8 April it contained 3 young (McIvor and McIvor 1980). A pair was seen carrying food, presumably to young, on 10 March 1980 near Jasper townsite (JLK). Young Gray Jays in their dark plumage have been observed between 4 May and 29 August.

HABITAT

The Gray Jay occurs from the montane ecoregion to treeline in the upper subalpine, but is most common in the lower subalpine ecoregion. It inhabits coniferous forests of all types but prefers closed forests, particularly those with pine. It also occurs in townsites, especially in winter.

During the summer the highest densities of Gray Jays were recorded in Engelmann spruce–subalpine fir/willow/ribbed bog moss (O6) open forest (DI=11.96), lodgepole pine/green alder/feathermoss (C10) forest (DI=10.40), lodgepole pine/buffaloberry/showy aster (C6) forest (DI=8.35) and Engelmann spruce–subalpine fir/false azalea (C14) forest (DI=8.13), as well as along the edges of dwarf birch–willow/kobresia (S9) meadows (DI=14.73).

BLUE JAY *Cyanocitta cristata* **BLJA**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: very rare visitor
Winter: very rare visitor

The Blue Jay breeds in North America east of the Rockies, from southern Canada to the southern United States (Godfrey 1966). It nests in central Alberta (Salt and Salt 1976).

There are no Jasper records of this species, although it has been observed near Hinton. In Banff, it has been seen sporadically at all seasons, although most often in the autumn and winter. Most records are from the lower and middle Bow River and lower Cascade River valleys. These include one or two individuals on 30 May 1977 (GLH), 7 June 1977 (GLH), 31 August 1954 (Woledge, BNP warden card), 14 September 1979 (GLH), 6 October 1974 (Salt and Salt 1976), 18 October 1947 (Stenton, BNP warden card), 1 December 1977 (DJK), 26 January 1975 (BNP warden card), 11 January to 3 May 1975 (McIvor and McIvor 1980), and 16 March 1947 (BNP warden card). The only other records are one on 30 June 1978 along the Pipestone River (MED), and three on 11 September 1973 at Trident Lake (Gordon 1975).

HABITAT

The Blue Jay inhabits "mixed and deciduous woodland of various types" (Godfrey 1966). Most Banff records have been from deciduous habitats.

STELLER'S JAY *Cyanocitta stelleri* **STJA**

STATUS AND DISTRIBUTION

Spring: rare resident
Summer: rare resident
Autumn: rare resident
Winter: rare resident

Steller's Jay breeds in extreme western North and South America from Alaska to Nicaragua (Godfrey 1966). In Alberta, it occurs in the Rocky Mountains where its status is not well known (Salt and Salt 1976).

In Banff and Jasper it appears to be a permanent resident. There are relatively few, but regular and widespread, sightings for both parks. It has been recorded with about equal frequency in all four seasons. There are 20 to 25 Banff records and 15 to 20 for Jasper; several are records dating back to the early 1900's, indicating its occurrence here is not a recent phenomenon. Records span from southern Banff to northernmost Jasper at Willow Creek, mostly along the western sides of both parks. The most frequent sightings occur at Jasper townsite, particularly in the autumn and winter. There are no records of nests or other breeding evidence.

HABITAT

Steller's Jay occurs in the montane and lower subalpine ecoregions. It inhabits mixed and coniferous forests and, to some extent, dense avalanche shrubbery. In the winter, it frequents townsites and visits feeders and garbage pails.

BLACK-BILLED MAGPIE *Pica pica* **(B)** **BLMA**

STATUS AND DISTRIBUTION

Spring: fairly common resident
Summer: fairly common resident
Autumn: fairly common resident
Winter: fairly common resident

The Black-billed Magpie breeds across Eurasia, in northern-most Africa, and in western North America from Alaska and central Manitoba to the south-central United States (Godfrey 1966). It breeds throughout Alberta except in the extreme north (Salt and Salt 1976).

In Banff and Jasper it is a permanent resident. Its range is restricted almost entirely to the lower and middle Bow River valley and the lower Athabasca River valley upstream to Jasper townsite. In Banff, small numbers are regularly seen along the lower and middle Cascade River and the lower Spray River. There is one record along the Panther River on 14 June 1967 (Gordon 1975). In Jasper, it is seen regularly in the Miette, Snaring and lower Maligne River valleys. A few early and late winter records at more remote localities indicate there is some dispersal of birds. The highest count recorded in Banff is 36 on 7 March 1979 near Banff townsite, and in Jasper is 35 on 17 January 1979 in the lower Athabasca River valley. Usually only small groups of up to ten are seen on any one occasion; however, more may be seen near food sources such as garbage dumps and railroad kills.

There is one Banff nest record, and several Jasper records. The earliest is a nest found on 1 April 1973 at Banff townsite (Gordon 1975). The earliest nestlings were 4 in a nest found on 26 May 1978 at Talbot Lake (KVT). The first record of fledged young were 4 seen with 2 adults on 11 July 1979 near Jasper townsite (DJH).

In 1891, Macoun recorded the magpie as "occasional at Banff in winter". In the 1940's it was considered "a common year-round resident in the Bow Valley" (Clarke and Cowan 1945). In Jasper, there is no mention of this species in reports prior to the 1940's; in 1944, one or two were seen at various times in the spring and summer, and in December up to 18 were seen in one day in the Athabasca valley (Cowan 1955).

HABITAT

The Black-billed Magpie occurs primarily in the montane ecoregion, but is occasionally seen in lower subalpine areas. It prefers open forests or forest edges, and shrubby areas. Being an opportunistic species that adapts readily to the presence of man, it is also common in townsites, at landfill sites, and along roadways where it scavenges on roadkills.

The highest densities of Black-billed Magpies recorded on call-count transects in June and July were in lodgepole pine savannah (DI=5.49) and dwarf birch-shrubby cinquefoil/needlerush (S3) wetlands (DI=3.64).

In winter 13 out of 21 Black-billed Magpies recorded during winter transects were on montane alluvial fans (.44/km).

MANAGEMENT CONSIDERATIONS

Garbage in towns and at dumps, and roadkills, contribute to the existence of Black-billed Magpies in the montane ecoregion. The magpie preys on eggs and young of other bird species, so unnaturally high numbers of magpies are not desirable, and could be reduced by stricter control of garbage and roadkills.

COMMON RAVEN *Corvus corax* **(B)** **CORA**

STATUS AND DISTRIBUTION

Spring: common resident
Summer: common resident
Autumn: common resident
Winter: common resident

The Common Raven breeds throughout most of the arctic and temperate areas of the world south to Nicaragua and Asia Minor (Godfrey 1966). It nests in northern Alberta and in the Rocky Mountains and their foothills; it is absent from the central plains (Salt and Salt 1976), except in winter.

The raven is a permanent resident throughout Banff and Jasper. Usually only from one to five are encountered at any time; however, large congregations occur in the vicinity of dumps and at dead ungulates. At such locations, flocks of 40 to 50 birds are not uncommon. The highest counts recorded are 200 ravens on 5 May 1977 at the Banff dump, and 81 on 9 May 1978 at the Jasper dump.

There are two Jasper nest records, one on 7 March 1980 in Maligne Canyon, and one on 20 April 1976 in an aspen in the upper Athabasca River valley. In Banff, a nest on 25 April 1979 near Waterfowl Lakes had 2 young about five days old on 19 May

(GLH). During the nesting season, the Common Raven tends to retreat to remote areas away from disturbance but may also nest in areas frequented by humans such as Maligne Canyon where up to 2 pairs nest annually (J. Todgham, Jasper Interpretive Service, pers. comm.).

Ravens are more common now than they were in the 1940's. Clarke and Cowan (1945) found only 2 records of a raven in Banff. There are no records of when it first became more numerous. In Jasper, ravens were "quite scarce" in the 1940's, and likely were not more numerous previous to this: the first recorded major invasion was in December 1946 (Cowan 1955).

HABITAT

In the summer, the Common Raven is most common in the montane and lower subalpine ecoregions, but occurs regularly up to and in the alpine. It is relatively ubiquitous and is found in all types of habitat. Forest edges, landfill sites, and roadways are preferred areas. Nests are usually on rock faces, but can also be in trees.

In the winter ravens are most common in montane valley bottoms where wintering ungulates concentrate, and at townsites and landfill sites.

MANAGEMENT CONSIDERATIONS

The increase of Common Ravens in the last 30 years is likely because of an increase in landfill sites and other areas where garbage is accessible, and increases in roadkills. A reduction of these factors would probably lead to a decrease in raven numbers, particularly in the vicinity of townsites.

COMMON CROW *Corvus brachyrhynchos* **(B)** **COCR**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: very common resident
Autumn: common migrant
Winter: rare visitor

The Common Crow breeds across North America from the southern half of Canada (except the West Coast) to southern parts of the United States (Godfrey 1966). It nests throughout Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from mid March to early May, peaking in April. The earliest record is an individual on 3 March 1975 at Banff townsite (H. Flygare, BNP warden card). The maximum count was 60 on 11 April 1979 in the lower Athabasca River valley.

In the summer crows are commonest in the lower and middle Bow River, lower North Saskatchewan River, lower and middle Athabasca River, and Miette River valleys. The occasional crow is encountered in other valleys. As at other seasons, the greatest numbers are usually seen near dumps. There are several nest records for both parks, although few recent ones. The earliest is a nest with 1 egg on 21 May 1979 along the lower Athabasca River (DJH). The earliest nestling record is 6 June 1943 at Lake Minnewanka (Clarke and Cowan 1945), and the earliest fledged young were 2 seen on 23 June 1978 (MJD).

Autumn migration occurs from late August to late October, peaking in mid to late September. Fewer than five were recorded on any one occasion after November. Maximum count is 257 birds on 12 September 1977 near Banff townsite. This is comparable to earlier records: on 12 August 1943 almost 100 crows were seen near Jasper Lake (Cowan 1955), and on 12 August 1944, 167 crows were recorded near Banff townsite (Green, BNP warden card). Flocks tend to be larger in the autumn than in the spring, but usually do not exceed 60.

Small numbers remain into the early winter, particularly in Banff, and occasional crows have been recorded throughout the winter. The maximum winter count of 34 crows was in mid December 1977 on the Banff Christmas Bird Count. In Jasper townsite one crow was seen regularly until 10 December 1979. There are four Banff and two Jasper records of 1 to 4 crows in January and February.

Crows have probably always been summer residents of Banff and Jasper. In the 1940's they were "common" in the Bow Valley (Clarke and Cowan 1945). Crows were "abundant" in the main Athabasca Valley in the 1940's, "but apparently no more so than in earlier years" (Cowan 1955).

HABITAT

The Common Crow occurs in the montane and, to a lesser extent, the lower subalpine ecoregions. It prefers open coniferous forests and forest edges near grassland or shrubberry, as well as townsites and dumps.

MANAGEMENT CONSIDERATIONS

The abundance of crows is partly due to landfill sites and other areas where garbage is accessible, and to frequent roadkills. A reduction of these factors may lead to a decrease in crow numbers.

CLARK'S NUTCRACKER *Nucifraga columbiana* **(B)** **CLNU**

STATUS AND DISTRIBUTION

Spring: fairly common resident
Summer: common resident
Autumn: fairly common resident
Winter: fairly common resident

Clark's Nutcracker breeds in western North America from British Columbia to northern Baja California (Godfrey 1966). It nests in southwest Alberta in the Rocky Mountains of southwestern Alberta (Salt and Salt 1976).

Clark's Nutcracker is a permanent resident throughout Banff and Jasper. It usually occurs singly or in small groups of up to 10 birds. Family groups are often seen in the summer. An unusually high maximum count of 277 was recorded in mid December on the 1978 Banff Christmas Bird Count; in other years, counts ranged from 10 to 204. The highest Banff count recorded other than on Christmas bird counts was 20 on 25 September 1979 in the upper North Saskatchewan River valley. For Jasper, the maximum counts were 100 and 35 at Jasper townsite on 22 November 1979 and 14 May 1977, respectively. High winter concentrations are usually near bird feeders.

There are no nest records but there are numerous records of fledged young with adults, the earliest being 17 June 1975 (JWW).

HABITAT

In the summer Clark's Nutcrackers occur most commonly in the lower and upper subalpine ecoregions, and only occasionally in the montane. An exception is Banff townsite where it is a regular summer resident and has been since the turn of the century (Clarke and Cowan 1945). It inhabits a variety of open and closed forests along steep slopes, and subalpine fir krummholz at timberline.

Highest densities recorded on call-count transects in June and July were in lodgepole pine/feathermoss (C11) (DI=10.33), subalpine fir-willow (S2) avalanche slopes (DI=6.16), lodgepole pine/false azalea/grouseberry (C20) (DI=3.91), Engelmann spruce-subalpine fir/grouseberry (C15) (DI=3.64), Engelmann spruce-subalpine fir/grouseberry (C15) (DI=3.48), and Engelmann spruce-subalpine fir/heather (O10) open timberline forest (DI=3.34).

In the winter most Clark's Nutcrackers descend to lower elevations or migrate out of the parks. During this season they frequent Douglas-fir and lodgepole pine forests in the montane ecoregion, and townsite areas.

MANAGEMENT CONSIDERATIONS

Clark's Nutcracker is usually present near many visitor use areas in the scenic subalpine ecoregion where it will interact with and is enjoyed by visitors. Unusually high numbers winter in Banff and Jasper townsites because of the availability of food at bird feeders.

BLACK-CAPPED CHICKADEE *Parus atricapillus* **(B)** **BLCH**

STATUS AND DISTRIBUTION

Spring: fairly common resident
Summer: fairly common resident
Autumn: fairly common resident
Winter: fairly common resident

The Black-capped Chickadee breeds across North America from Alaska, the Yukon and southeastern Canada south to the central and northeastern United States (Godfrey 1966). It nests throughout Alberta (Salt and Salt 1976).

It is a permanent resident throughout Banff and Jasper. It is most common in the lower valleys, particularly those of the lower and middle Bow River and the lower Athabasca River. In the breeding season it is usually encountered singly or in pairs. At other seasons it tends to congregate in flocks of up to 15, often mixed with other species. It is less common and less widely distributed than the other two chickadee species.

There are two nest records for each park, the earliest being one found on 21 May 1979 near the lower Bow River (KAM). The earliest nestlings were on 3 June 1978 along the lower Athabasca River (DJH). Fledged young were first seen on 28 June 1975 in the middle Bow River valley (JWW).

HABITAT

The Black-capped Chickadee is most common in the montane ecoregion, particularly in the winter, but also occurs in the lower and upper subalpine ecoregions. It prefers

deciduous habitats such as tall willow groves, aspen and balsam poplar forests, and forests of white spruce or lodgepole pine with some deciduous trees or willows.

During the breeding season highest densities are in aspen/hairy wild rye-peavine (C16) forest (DI=7.21), aspen-lodgepole pine forest (DI=5.61) and willow/horsetail (S7) thickets (DI=5.61).

In winter Black-capped Chickadees occur at highest densities on montane alluvial fans with lodgepole pine (1.83/km.) or aspen/hairy wild rye-peavine (C16) (1.00/km.) forest. It also inhabits montane wetlands with balsam poplar-white spruce forest, ridged terrain with Douglas-fir and aspen forest, south-facing montane slopes with Douglas-fir, aspen and white spruce forest, and glaciofluvial terraces with pine forest, in the montane ecoregion.

MOUNTAIN CHICKADEE *Parus gambeli* **(B)** **MOCH**

STATUS AND DISTRIBUTION

Spring: common resident
Summer: common resident
Autumn: common resident
Winter: fairly common resident

The Mountain Chickadee breeds in the mountains of western North America from northern British Columbia south to Northern Baja California (Godfrey 1966). It nests in southwest Alberta in the Rockies (Salt and Salt 1976).

The Mountain Chickadee is a permanent resident throughout Banff and Jasper. In the summer it is usually encountered singly or in pairs. At other seasons it often congregates in small flocks of less than 10, sometimes mixed with other chickadee species. The largest flock recorded was 35 birds on 23 September 1977 at Johnston Creek (GLH). Some move into the foothills for the winter (Salt and Salt 1976).

There are one Banff and two Jasper nest records, the earliest being a nest found on 29 May 1979 in the lower Bow River valley (JLK). The earliest nestling record is a nest with "newly hatched young" found on 2 June 1946 near Edith Lake; on 30 June the same nest contained 5 eggs (Cowan 1955), indicating that the pair nested twice that year.

HABITAT

The Mountain Chickadee occurs primarily in the montane, but ranges well into the upper subalpine ecoregion at all seasons. There is some movement to lower elevations in the winter. It inhabits all types of coniferous forests.

During the breeding season the highest densities of Mountain Chickadees are in Douglas fir/hairy wild rye (C1) forest (DI=6.67), aspen-lodgepole pine forest (DI=6.42), white spruce/prickly rose/horsetail (C4) forest (DI=6.08) and dry pine forests (DI=6.00 and 4.32). Engelmann spruce-subalpine fir forests sustain somewhat lower densities.

In winter the greatest densities of this species are in ridged montane areas with Douglas-fir forest and clumps of aspen and pine (0.44/km.), shrubby upper subalpine areas with scattered spruce and subalpine fir (0.39/km.), and lower subalpine slopes with lodgepole pine-spruce forest (0.31/km.).

BOREAL CHICKADEE *Parus hudsonicus* **(B)** **BOCH**

STATUS AND DISTRIBUTION

Spring: common resident
Summer: very common resident
Autumn: common resident
Winter: common resident

The Boreal Chickadee breeds across North America from treeline south to the northern United States (Godfrey 1966). It nests in northern and western Alberta (Salt and Salt 1976).

It is a permanent resident throughout Banff and Jasper. In the summer it is usually encountered singly or in pairs, although small flocks are not unusual. At other seasons, it often occurs in flocks of up to 10, sometimes mixed with other chickadee species. The maximum count was a flock of twenty on 30 January 1980 in the lower Red Deer River valley. This is the most common of the chickadee species in Banff and Jasper.

There are no Banff nest records. There are several Jasper nest records, the earliest being a nest with eggs found on 18 April 1943 in the middle Bow River valley (JWW).

HABITAT

The Boreal Chickadee occurs from the montane to the upper subalpine ecoregion, but is most common in the lower subalpine. It inhabits all types of coniferous forests.

Highest densities during the breeding season are in Engelmann spruce–subalpine fir open forests, particularly Engelmann spruce–subalpine fir/willow/hairy wild rye (O18) forest (DI=14.51) and Engelmann spruce–subalpine fir/rock willow/bracted lousewort (O14) forest (DI=13.19). Other habitats which sustain high densities of Boreal Chickadee include white spruce/prickly rose/horsetail (C4) (DI=12.22), Engelmann spruce–subalpine fir/hairy wild rye–heartleaf arnica–twinflower/feathermoss (C31) (DI=10.48), lodgepole pine/Labrador tea (C29) (DI=10.36), lodgepole pine/buffaloberry/grouseberry (C18) (DI=9.96) and Engelmann spruce–subalpine fir/feathermoss (C13) forest (DI=9.39).

In winter flocks of Boreal Chickadees, often with other species, range widely through the parks. Highest densities are recorded in white spruce forest on montane slopes (2.19/km.), Engelmann spruce–subalpine fir forest on bouldery lower subalpine slopes (1.08/km.) and lodgepole pine–spruce forest on lower subalpine alluvial fans (1.02.km.). Boreal Chickadees were recorded in 59 ecosites sampled by winter track transects.

CHESTNUT-BACKED CHICKADEE *Parus rufescens* **CBCH**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare visitor
Winter: not recorded

The Chestnut-backed Chickadee occurs in the wet coastal and interior forests of British Columbia, Washington, Idaho, Montana and California (Godfrey 1966). Salt and Salt (1976) considered it a hypothetical species in Alberta.

The first record of this species in Alberta was reported by R.D. Ussher. He observed a single Chestnut-backed Chickadee in a mixed flock of the three common species at the Kananaskis Centre east of Banff in 1939 (Ussher 1940).

Two were seen in Waterton Lakes National Park in September 1973 by Carson Wade, and three were seen from 23 December 1979 until 18 March 1980 by several observers (S. Lunn, Waterton Lakes National Park, pers. comm.). The first documented occurrence of this species in Banff and Jasper was series of photographs by Reinhold Lang of a Chestnut-backed Chickadee at his feeder in Banff townsite on 31 October 1981 (Holroyd 1982). H.Mortimer had an individual at his feeder in Banff in December 1978

All Alberta records to date have been in autumn and winter. There is no evidence to suggest that the species has bred here.

WHITE-BREASTED NUTHATCH *Sitta carolinensis* **WHNU**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: very rare visitor
Winter: very rare visitor

The White-breasted Nuthatch breeds across most of North America from parts of southern Canada south to southern Mexico, excluding much of the Great Plains (Godfrey 1966). Before 1950 it was rarely seen in Alberta, but has become increasingly widespread in southern and central parts of the province (Salt and Salt 1976).

There are no Jasper records. In Banff it is a regular, although scarce, visitor. All records have been since 1970 and are from the lower and middle Bow River valley, particularly around Banff townsite. Spring records include: one on 18 March 1978 (McIvor 1980), one on 2, 3 and 9 March 1975 (BNP warden cards) and one on 4, 20, 24 and 30 May 1977 (KAM). In the breeding season, three were heard on 13 June 1977 (KAM).

There are about 10 autumn records of from one to three birds, the earliest being one on 29 September 1977 at Banff townsite (McIvor and McIvor 1980). White-breasted Nuthatchs have been recorded in all months up to December. From four to seven birds have been recorded each year from 1976 to 1980 in mid December on Banff Christmas Bird Counts.

HABITAT

The White-breasted Nuthatch occurs in the montane ecoregion. It usually prefers deciduous woods, but has also been observed in lodgepole pine and Douglas-fir forests.

RED-BREASTED NUTHATCH *Sitta canadensis* **(B)** **RENU**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: fairly common resident
Autumn: fairly common migrant
Winter: uncommon resident

The Red-breasted Nuthatch breeds in coniferous forests across North America from Alaska and Canada south to the northern United States and, in the mountains, to California (Godfrey 1966). It nests in northern and western Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from late April to late May, peaking in mid May. The maximum count is 13 on 17 May 1977 in the lower Bow River valley. It is usually encountered singly or in small groups of up to three.

In the summer it occurs throughout both parks, but is slightly more common in the Bow River and Athabasca River valleys. There is only one nest record, a nest with 2 young on 1 August 1979 in the middle Bow River valley (GRB). On 13 June 1944 a Red-breasted Nuthatch was excavating a nest cavity near Jasper townsite, but this was abandoned before eggs were laid (Cowan 1955). A fledged young was seen on 16 August 1979 in the lower Rocky River valley (EJE).

Autumn migration occurs in August and September. The maximum count is 24 on both 7 August 1977 and 16 September 1976 in the middle Athabasca River valley. They are usually encountered singly or in flocks of up to 10 birds.

Small numbers remain through the winter in both parks. Up to five have been recorded on any one occasion in several watersheds, particularly near townsites and along the Rocky River. From 2 to 12 are regularly recorded in late December on Banff Christmas Bird Counts.

HABITAT

The Red-breasted Nuthatch occurs in the montane and lower subalpine ecoregions and to a lesser extent, the upper subalpine ecoregion. It inhabits closed coniferous forests. On migration it is sometimes found in deciduous trees with other small migrants.

Highest densities during the breeding season are in aspen-lodgepole pine forest (DI=3.91), Douglas fir/hairy wild rye (C1) forest (DI=3.17), white spruce/buffaloberry/fern moss (C26) forest (DI=3.10), white spruce/shrubby cinquefoil/bearberry (O3) forest (DI=2.61) and lodgepole pine/Labrador tea (C29) forest (DI=2.52).

Of 26 Red-breasted Nuthatchs recorded on winter transects, 18 were in lower subalpine alluvial areas and 14 were in Engelmann spruce-subalpine fir or lodgepole pine-spruce forest; none were in pure lodgepole pine.

PYGMY NUTHATCH *Sitta pygmaea* **PYNU**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: not recorded
Winter: very rare visitor

The Pygmy Nuthatch breeds in the mountains of western North America from southern British Columbia south to central Mexico (Godfrey 1966). There are no previous Alberta records but it occurs regularly in the area north of Cranbrook B.C.

There is one Banff record of this species. One was observed on 19, 20 and 28 December 1976 by H. Mortimer (pers. comm.) at his bird feeder in Banff townsite. On 28 December a Red-breasted Nuthatch and a White-breasted Nuthatch were at his feeder at the same time as the Pygmy Nuthatch. The three species were compared and identification of the Pygmy Nuthatch was considered certain.

BROWN CREEPER *Certhia familiaris* **(b)** **BRCR**

STATUS AND DISTRIBUTION

Spring: uncommon resident
Summer: uncommon resident
Autumn: uncommon resident
Winter: rare resident

The Brown Creeper is widely distributed throughout the Northern Hemisphere. In North America it breeds in most wooded parts (Godfrey 1966). It nests in central Alberta and the Rocky Mountains (Salt and Salt 1976).

The Brown Creeper is a permanent resident of Banff and Jasper, although it is less common during the winter. It occurs throughout Banff and southern parts of Jasper. There are about ten records from the northern two-thirds of Jasper. There is some movement of autumn migrants after mid September, with creepers returning in April and May. From one to three were encountered on any one occasion. A maximum of 13 was recorded in the Banff townsite vicinity on the 1978 Banff Christmas Bird Count; elsewhere maximum counts did not exceed three.

There are no nest records. However, "a family group of five or six birds was seen" near Beaver Lake on 23 July 1944 (Cowan 1955).

HABITAT

The Brown Creeper occurs in the montane and lower subalpine ecoregions. It inhabits mature coniferous forests, particularly Engelmann spruce-subalpine fir and lodgepole pine-spruce stands.

Out of 13 Brown Creepers recorded on winter transects, 6 were in the lower subalpine and 5 in the upper subalpine ecoregions with most (7) being in Engelmann spruce-subalpine fir forest.

AMERICAN DIPPER *Cinclus mexicanus* **(B)** **DIPP**

STATUS AND DISTRIBUTION

Spring: fairly common resident
Summer: fairly common resident
Autumn: fairly common resident
Winter: uncommon resident

The American Dipper breeds in the western mountains of North and Central America from Alaska to Panama (Godfrey 1966). In Alberta, it nests in the Rockies (Salt and Salt 1976).

The dipper is a permanent resident of Banff and Jasper; however, only some of the summer residents remain the entire winter. Spring migration occurs in April and May. Dippers are usually solitary, although they may be fairly densely concentrated along stretches of open river in winter and early spring.

In the summer they occur throughout both parks (Figures 3.22, 3.23). Although usually solitary, at this time family groups may be seen. There are numerous nest records from Banff, and several from Jasper. The earliest is a nest found empty on 15 May but containing 2 eggs on 17 May 1977 along the lower Cascade River (GLH). The earliest nestlings were two recorded on 31 May 1975 in the middle Bow River valley (JWW). The first fledged young was on 14 July 1977 at the Alexandra River (DJK).

A type specimen of American Dipper was collected "... near the Rocky Mountains on the Athapascow Lake = near the source of the Athabasca River... " (AOU 1957; pg 405).

Autumn migration is in October and November. Dippers are usually encountered singly, although occasionally two or three are seen.

In the winter, they occur throughout both parks wherever there is open water, even a small stretch. Highest densities are along the Bow and Athabasca Rivers. The lower Bow River has the highest density of wintering dippers recorded in Canada.

HABITAT

In the summer, the dipper occurs along streams and rivers, primarily in the lower and upper subalpine ecoregions. It nests near water in rocky banks and canyons, often beside rapids, behind waterfalls or under bridges.

It winters wherever there is open water, concentrating along large rivers in the montane and lower subalpine ecoregions.

MANAGEMENT CONSIDERATIONS

Because dippers concentrate in winter along the Bow and Athabasca Rivers in the vicinity of and downstream from Banff and Jasper townsites, water quality here should be maintained. Anything which is allowed to damage dipper wintering habitat in Banff and Jasper will have far-reaching effects in summer since dippers from large parts of each park tend to concentrate in these small areas in winter.

Figure 3.22. Distribution of American Dipper observations in Banff, summer and winter.

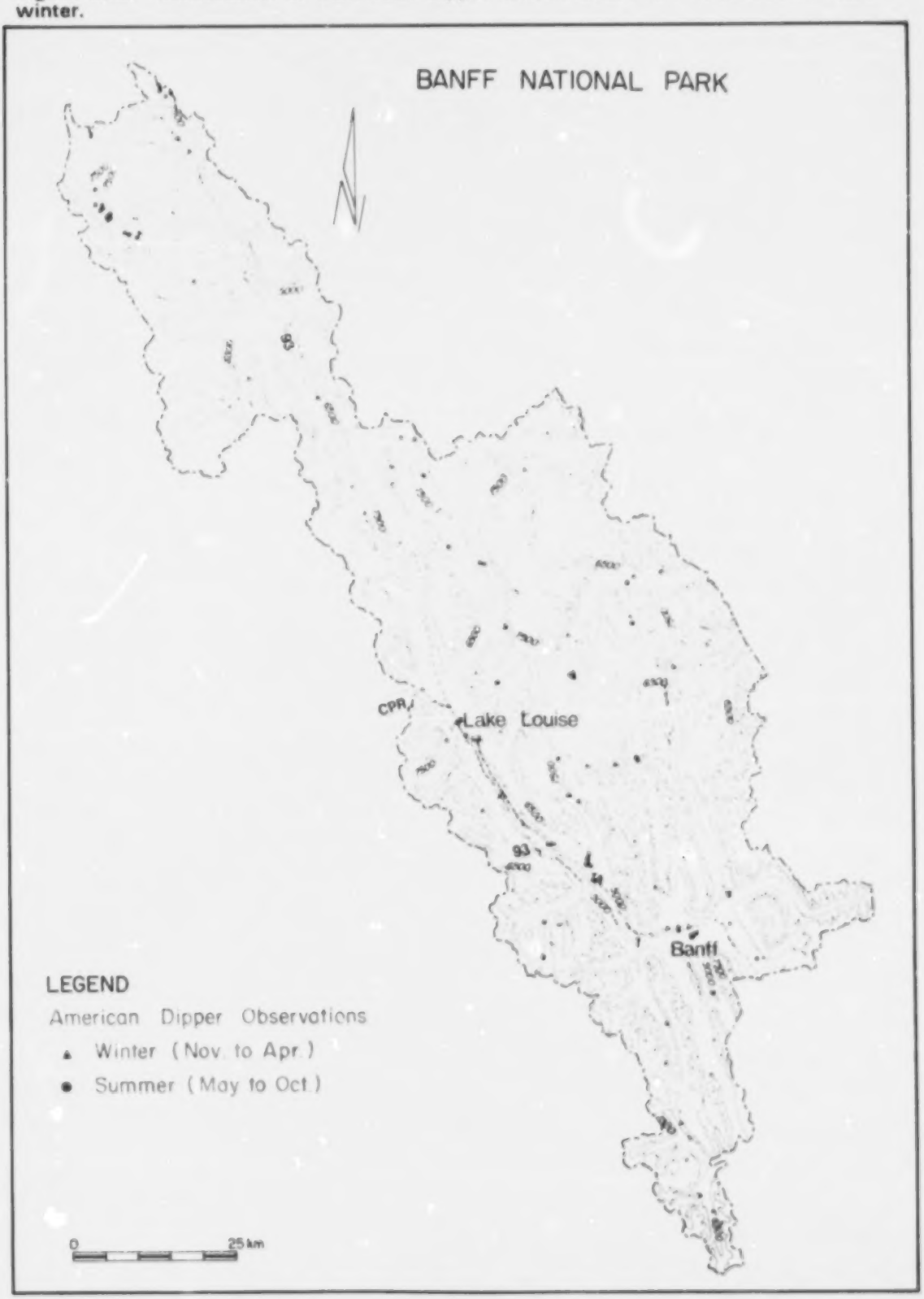
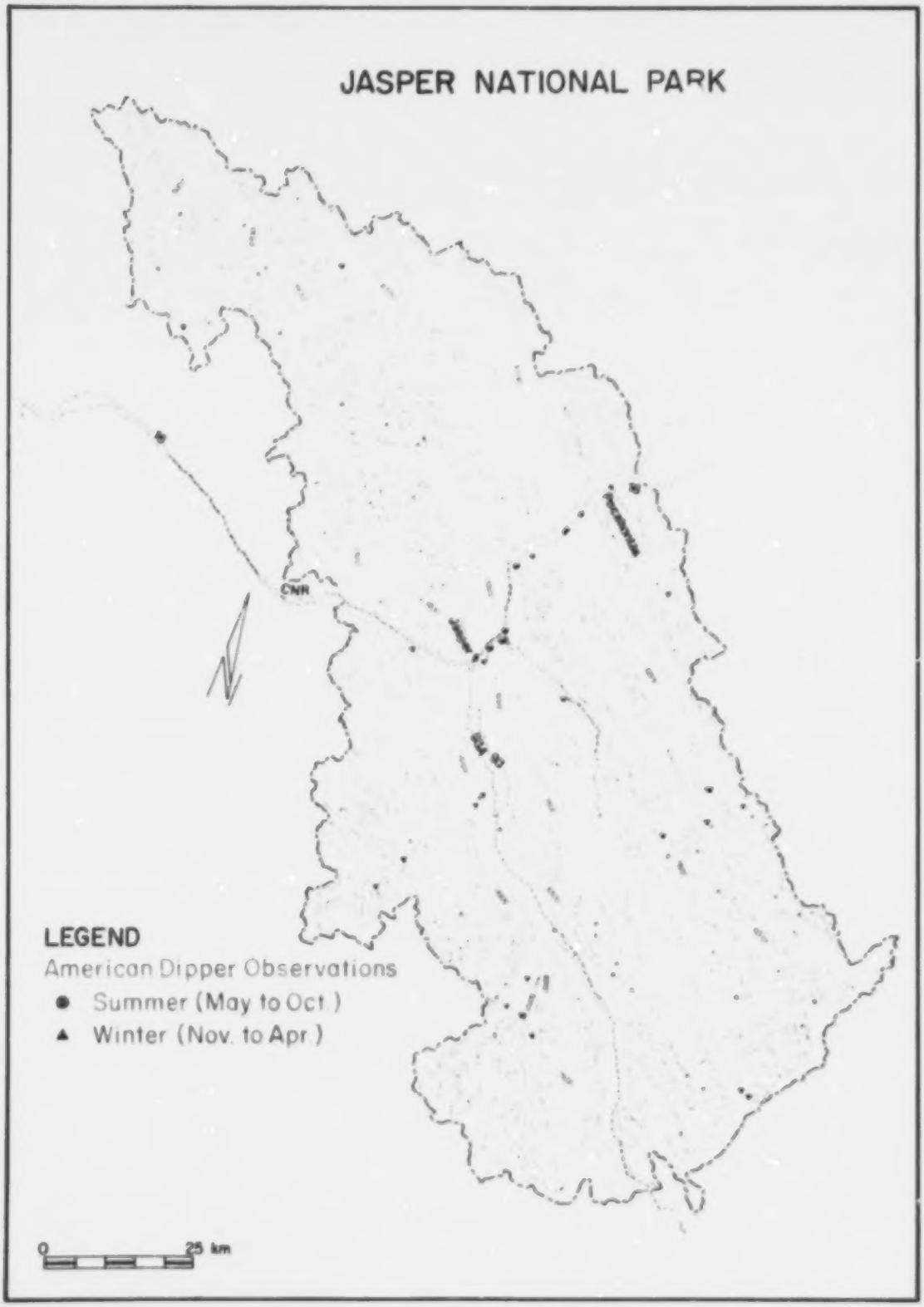


Figure 3.23. Distribution of American Dipper observations in Jasper, summer and winter.



HOUSE WREN *Troglodytes aedon* HOWR

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: very rare resident
Autumn: not recorded
Winter: not recorded

The House Wren breeds in North America from southern Canada to southern parts of the United States (Godfrey 1966). It breeds throughout Alberta, but only locally in the far north, Rocky Mountains and prairies (Salt and Salt 1976).

There are no Jasper records. There is one Banff record of this species: one was recorded on 5 May 1965 at Banff townsite (Gordon 1975). The House Wren has evidently occurred in Banff before; it was considered "rare" at Banff in June 1891 by Macoun (Clarke and Cowan 1945).

WINTER WREN *Troglodytes troglodytes* **(B)** WIWR

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: fairly common resident
Autumn: uncommon migrant
Winter: very rare resident

The Winter Wren breeds in much of North America and Eurasia; it occurs across North America from Alaska and southern Canada south to northern California and Georgia (Godfrey 1966). It nests in the northern third of Alberta and in the Rocky Mountains (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from mid April to late May, with a slight peak in early May. The earliest record of two on 14 April 1977 and the maximum count of six on 9 May 1976 were along the lower Maligne River valley.

In the summer it occurs throughout the Main Ranges of both parks. The occasional bird is encountered in Front Range valleys. There is only one nest record. On 2 July 1979 a nest containing young was found on the Johnston Canyon Trail (M.McNicholl). An adult was seen carrying food, presumably to young, on 3 July 1980 in the Snaring River watershed (GRB).

Autumn migration occurs in August. The latest and only September record is 20 September 1965 near Lake Louise (Gordon 1975). Only one or two were seen on any one occasion.

There are two records from late December: one was recorded on each of the 1976 Banff and 1978 Jasper Christmas Bird Counts.

HABITAT

The Winter Wren occurs in the lower and upper subalpine ecoregions, mostly in the moister forests of the Main Ranges. It is almost exclusively found in Engelmann spruce-subalpine fir forests. Winter wrens remain close to the ground, usually in dense

tangles of undergrowth adjacent to streams or springs.

Highest densities of Winter Wrens during the breeding season are in Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) forest (DI=6.99), Engelmann spruce-subalpine fir/false azalea (C14) forest (DI=4.26), lodgepole pine/Labrador tea (C29) forest (DI=3.80) and subalpine fir-willow (S2) avalanche slopes (DI=3.54).

LONG-BILLED MARSH WREN *Telmatodytes palustris* **LOWR**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: very rare visitor
Winter: not recorded

The Long-billed Marsh Wren breeds across North America from southern Canada to southern parts of the United States (Godfrey 1966). It nests locally throughout Alberta except in the Rocky Mountains (Salt and Salt 1976).

There are two Banff records of this species: one on 30 April 1978 at Vermilion Lakes, and one on 8 October 1979 at Banff townsite (McIvor and McIvor 1980). There is one Jasper record: a singing male was seen on 21 June 1978 at Talbot Lake (KVT).

HABITAT

The Long-billed Marsh Wren frequents "cattail, tule, and bulrush shallow-water marshes" (Godfrey 1966). In Banff and Jasper Long-billed Marsh Wrens were recorded in emergent sedge vegetation and a cattail stand in montane wetlands.

ROCK WREN *Salpinctes obsoletus* **(b?)** **ROWR**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: rare resident
Autumn: very rare migrant
Winter: not recorded

The Rock Wren breeds in western North America and Central America from Alberta and interior south British Columbia south to Costa Rica (Godfrey 1966). It nests locally in southern Alberta "and, in the Rockies, north to Jasper" (Salt and Salt 1976).

There are two Banff records: a singing male was heard on 7 June 1978 in the lower North Saskatchewan River watershed (MED), and one was recorded on 5 July 1977 near Healy Creek (J. Podlubny, pers. comm.). There are two recent Jasper records: a singing male was seen on 28 June 1980 near Snake Indian Pass (GRB), and a singing male was seen on 2 July 1978 at Windy Point in the lower Athabasca River valley (KVT).

There are several old records for Jasper including, in the lower Athabasca River valley, one seen in "the early autumn" of 1895, a pair seen (male singing) on 28 June 1944, and a singing male heard on 5 June 1946; in the middle Athabasca River valley a

pair was encountered on 4 July 1945 (Cowan 1955).

HABITAT

The Rock Wren occurs in the montane and lower subalpine ecoregions. It inhabits rock slides and rock bluffs in open areas which are exposed to the sun.

NORTHERN MOCKINGBIRD *Mimus polyglottos* **NOMO**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Mockingbird breeds very locally in parts of southern Canada, and is resident from the north and north-central United States south to southern Mexico (Godfrey 1966). It was first recorded in Alberta in 1928, and now occurs locally and irregularly in south-central parts east of the Rockies (Salt and Salt 1976).

There are no Jasper records. There are two records of this species in Banff: a singing male was seen on 28 June 1976 at Banff townsite (G. Wapple, pers. comm.), and one on 15 May 1977 at Vermilion Lakes (Bow Valley Naturalists 1978). No photographs or specimens support these observations.

HABITAT

The Mockingbird inhabits "shrubbery and tangles, hedgerows, (and) various kinds of ornamental shrubbery about buildings" (Godfrey 1966).

GRAY CATBIRD *Dumetella carolinensis* **GRCA**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Gray Catbird breeds across North America from southern Canada south to Oregon, Texas and Florida (Godfrey 1966). It nests in the southern half of Alberta west to the foothills of the Rockies (Salt and Salt 1976).

There is one undocumented Jasper record from Cottonwood Slough (Jasper National Park interpretive service). There are three records of this species in Banff: one on 5 June 1966 at Vermilion Lakes (Gordon 1975), one on June 1975 in the middle Bow River valley (JWW) and one on 21 July 1978 at Vermilion Lakes (T. Lang, pers. comm.).

HABITAT

The Gray Catbird frequents "low, dense deciduous thickets (occasionally coniferous) along streams, ponds, roadsides, woodland edges, and prairie coulees" (Godfrey 1966). All Banff and Jasper records have been in the montane ecoregion where suitable habitat occurs in the form of willow shrubbery along the edges of streams and wetlands.

AMERICAN ROBIN *Turdus migratorius* **(B)** **AMRO**

STATUS AND DISTRIBUTION

Spring: very common migrant
Summer: very common resident
Autumn: common migrant
Winter: rare resident

The American Robin breeds across North America from treeline in Alaska and Canada south to southern Mexico (Godfrey 1966). It nests throughout Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from early April to mid May, peaking in late April and early May. The earliest record is one on 17 February 1979 at Banff townsite (J. Beleyne, Banff National Park warden card), but the first robins are usually seen here in March. The maximum count and largest flock was 150 birds on 28 April 1946 on the CPR station lawn at Lake Louise (Woodworth, Banff National Park warden card). The maximum recent count of 129 birds was on 3 May 1978 in the lower Bow River valley. Flocks of up to 50 birds are not uncommon. The American Robin is the most common spring migrant in Banff and Jasper.

In the summer it is ubiquitous throughout both parks. There are numerous nest records for Banff and Jasper spanning late March to early July. There is a very early nest record of 24 March 1908 at Banff townsite (Clarke and Cowan 1945). The next earliest record is a nest with 3 eggs found on 11 May 1976 in the lower Maligne River valley (GLH). The earliest nestlings recorded were on 8 June 1978 near North Saskatchewan River Crossing (MJD). Fledged young were first seen on 2 June 1914 at Banff townsite (Clarke and Cowan 1945), and on 14 June 1979 in the lower Red Deer River valley (HFC). This is the most common thrush in Banff and Jasper.

Autumn migration occurs in September and October, peaking in late September and early October. Few are seen after October. The maximum count was 221 birds on 29 September 1976 near the Valley of Five Lakes in the middle Athabasca River valley. In Banff, the largest flock of 60 birds was seen on 15 September 1979 in the lower Cascade River valley. Flocks usually consist of up to 25 birds. This is the most common autumn thrush.

In the early winter, the occasional late straggler is seen in November and December. One robin was recorded on the Banff Christmas Bird Count in late December of 1975, 1976 and 1978. One robin was seen on 17 February 1979 at Banff townsite but most probably fail to survive the winter.

HABITAT

The American Robin occurs from the montane to treeline in the upper subalpine ecoregion; occasionally it is seen foraging in the alpine ecoregion. It inhabits townsites and all types of forests and forest edges, but is markedly less common in forests than elsewhere. It forages in a variety of open habitats including grassy meadows, roadsides, townsite lawns, wetlands and alpine meadows.

Highest densities during the breeding season are in open subalpine larch/heath forest (DI=29.26), white spruce/prickly rose/horsetail (C4) forest (DI=27.53), aspen/hairy wild rye-peavine (C16) forest (DI=23.95) and Douglas fir/hairy wild rye (C1) forest (DI=20.63).

VARIED THRUSH *Ixoreus naevius* **(B)** **VATH**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: fairly common resident
Autumn: uncommon migrant
Winter: not recorded

The Varied Thrush breeds in western North America from Alaska and northwestern Mackenzie south to California and Idaho (Godfrey 1966). In Alberta it nests throughout the Rocky Mountains (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from early April to mid May, peaking in late April and early May. The earliest records are 12 March 1908 in Banff Park (Clarke and Cowan 1945) and 15 March 1979 at Banff townsite (McIvor and McIvor 1980). The maximum count is 72 birds on 19 April and 6 May 1977 along the middle Athabasca River valley and on 16 May 1977 along the upper Bow River valley. It is usually encountered singly or in pairs. Next to the American Robin, this is the most common spring thrush, and is one of the most common migrants overall.

In the summer it occurs throughout both parks. There are no Banff nest records. There is one for Jasper: a nest was found on 27 June 1978 in the Whirlpool River valley (KVT). A fledged young was seen with an adult on 6 August 1979 in the Southesk River valley (DJH).

Autumn migration occurs in September and October. The latest record is one on 14 November 1977 at Vermilion Lakes (Bow Valley Naturalists 1978). The maximum count is seven on 6 October 1976 in the middle Athabasca River valley.

HABITAT

The Varied Thrush occurs in the lower and, to a lesser extent, upper subalpine ecoregions; occasionally it is found in the montane ecoregion. It inhabits moist, mature coniferous forests, particularly Engelmann spruce-subalpine fir stands in the Main Ranges.

Highest densities during the breeding season are in lodgepole pine-(Engelmann spruce)/crowberry/lichen (C35) forest (DI=4.99), Engelmann spruce-subalpine fir/false azalea (C14) forest (DI=3.95), Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21) forest (DI=3.94), Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14) forest (DI=3.17) and Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) forest (DI=2.67).

HERMIT THRUSH *Catharus guttata* **(B)** **HETH**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: common resident
Autumn: uncommon migrant
Winter: not recorded

The Hermit Thrush breeds across North America from Alaska and most of forested Canada south to California and Maryland (Godfrey 1966). It nests in wooded areas of northern and western Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in May. The earliest record is one on 3 May 1978 in the lower Maligne River valley. Only one to three were recorded on any one occasion.

In the summer it occurs throughout both parks. There is one Banff nest record and three records for Jasper, the earliest being a nest on 18 June 1978 at Lick Creek in the upper Athabasca River drainage (DJH). A nest with 4 young was found on 2 July 1943 at Sawback Lake in the upper Cascade River drainage (Clarke and Cowan 1945). The earliest fledged young was seen on 21 July 1976 in the Sunwapta River valley (DJK). This is one of the common summer thrushes.

Autumn migration occurs in September. The latest record is 6 October 1976 in the middle Athabasca River valley. Only one or two were recorded on any one occasion.

HABITAT

The Hermit Thrush occurs in the lower and upper subalpine ecoregions, and occasionally in the montane and alpine ecoregions. It is most common in Engelmann spruce–subalpine fir forests, but also inhabits other coniferous forests. It is more common in the upper subalpine ecoregion than Swainson's Thrush and is one of the common timberline birds.

During the breeding season, highest densities of Hermit Thrushes are in Engelmann spruce–subalpine fir/tall bilberry/liverwort (C21) forest (DI=6.03), Engelmann spruce–subalpine fir/valerian–fleabane (09) forest (DI=5.97), subalpine fir–willow (S2) avalanche slopes (DI=5.73) and spruce–fir/willow open forest (DI=5.12).

SWAINSON'S THRUSH *Catharus ustulata* **(B)** **SWTH**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: very common resident
Autumn: fairly common migrant
Winter: not recorded

Swainson's Thrush breeds across North America from Alaska and forested Canada south to California in the mountains, and to the northern United States in the east (Godfrey 1966). It nests in wooded areas of northern and western Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper is in May, peaking in late May. The earliest record is 1 May 1977 near the lower Cascade River. The maximum count is 26 on 31 May 1976 along the middle Athabasca River valley. It was almost invariably encountered singly or in groups of two or three.

In the summer it occurs throughout both parks. It is especially common throughout the Bow River and Athabasca River valleys, and is noticeably scarce in Jasper north of the Miette and lower Athabasca Rivers. There are no Jasper nest records; however, an adult was seen carrying nesting material on 7 June 1978 in the lower Athabasca River valley (MAS), and "young just out of the nest" were seen on 22 July 1944 in the Rocky River valley (Cowan 1955). There are two Banff nest records: a nest with 4 eggs on 19 June 1977 in the lower Bow River valley (J. Podlubny, pers. comm.), and a nest with 2 young on 12 July 1978 near the Howse River (MJD). The earliest fledged young were seen on 12 July 1978 near the Howse River (KAM). Next to the American Robin, this is the most common summer thrush.

Autumn migration occurs in late August and September. The latest record is on 16 September 1976 and the maximum count is seven on 27 August 1976 in the middle Athabasca River valley.

HABITAT

Swainson's Thrush occurs in the montane and lower subalpine ecoregions, and occasionally in the upper subalpine ecoregion. It inhabits all types of forests, but is more common in Douglas-fir, lodgepole pine and lodgepole pine-spruce, and in mixed deciduous/coniferous stands than in pure deciduous or Engelmann spruce-subalpine fir forests.

During the breeding season, highest densities of Swainson's Thrushes are in aspen-lodgepole pine forest (DI=22.32), white spruce/buffaloberry/fern moss (C26) forest (DI=14.10), lodgepole pine/false azalea/grouseberry (C20) forest (DI=14.02), white spruce/prickly rose/horsetail (C4) forest (DI=13.05) and Douglas fir/hairy wild rye (C1) forest (DI=9.16).

GRAY-CHEEKED THRUSH *Catharus minimus* **GRTH**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: rare visitor
Autumn: not recorded
Winter: not recorded

The Gray-cheeked Thrush breeds from northeastern Siberia across northern North America from near treeline in Alaska and Canada south to northern parts of some provinces, and in the extreme northeast United States (Godfrey 1966). It is a migrant throughout Alberta, and may breed in the far north (Salt and Salt 1976).

There are one recent Banff and 3 recent Jasper records, none substantiated. A singing male was heard at Amethyst Lakes in the Tonquin valley from 12 to 14 July 1976 (A. Strepniewski) and on 13 July 1978 (Haddow et al. 1978). At the head of the Snaring River, 3 males were singing on 1 July 1980 (GRB). In Banff, 1 singing male was heard on 19 June 1979 in the lower Red Deer River valley (GRB). Gordon (1975) states that it "has been observed at Bow Summit as a migrant."

Apparently the Gray-cheeked Thrush was formerly more common in Banff. Clarke and Cowan (1945) considered it "common at high altitudes and evidently fairly well distributed;" a specimen referred to was collected on 9 June 1943 at the head of Brewster Creek.

HABITAT

The recent Jasper observations of the Gray-cheeked Thrush were near timberline in the upper subalpine ecoregion in wet Engelmann spruce-subalpine fir open forests with lush herbaceous understories. The Banff record, possibly a late migrant, was in a lower subalpine pine forest.

VEERY *Hylocichla fuscescens* **VEER**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Veery breeds across North America (except along the west coast) in southern Canada and the northern United States (Godfrey 1966). It nests in the southern half of Alberta west to the mountains (Salt and Salt 1976).

There are no Jasper records. There are two or three recent Banff records: one on 1 June 1974 at Vermilion Lakes (Gordon 1975), one on 29 June 1977 at Bryant Creek (KAM), and a "tentative" record for July 1975 at Vermilion Pass (O'Keeffe 1975). "Macoun records one pair observed at Banff in the summer of 1891" (Clarke and Cowan 1945).

HABITAT

The Veery inhabits "deciduous or deciduous-coniferous woodland, especially where more open with an understory of deciduous shrubbery" (Godfrey 1966). Potential habitat in Banff is confined to the balsam poplar stands near Vermilion Lakes and aspen stands in the lower Bow River valley.

EASTERN BLUEBIRD *Sialia sialia* **EABL**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Eastern Bluebird breeds in eastern North America from Saskatchewan to Nova Scotia and south through the eastern United States and Mexico to Nicaragua (Godfrey 1966). Salt and Salt (1976) considered its occurrence in Alberta to be hypothetical however, in June 1977 a pair spent several days investigating nest boxes west of Calgary and were photographed by Rudi Butot (Butot 1978). This pair left the area on 12 June.

There are no Jasper records. There are two Banff records, a pair seen on 24 March 1979 at Vermilion Lakes (MAS), and a male seen on 14 June 1975 along the lower Bow River just upstream from the Vermilion Lakes (JWW).

HABITAT

The Eastern Bluebird inhabits "open and sparse woods, wood edges, (and) burntland with old standing trees" (Godfrey 1966). The Banff records are from open areas in the montane ecoregion.

WESTERN BLUEBIRD *Sialia mexicana* **WEBL**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: not recorded
Autumn: not recorded
Winter: not recorded

The Western Bluebird breeds in western North America from southern British Columbia and central Montana south through the mountains to southern Mexico (Godfrey 1966). Salt and Salt (1976) report no records of its occurence in Alberta.

There are no Jasper records. There are two Banff sight records, both from the middle Bow River valley: three were seen on 27 March 1966 west of Banff townsite (Sadler and Myres 1976), and a pair was seen on 29 May 1977 near Silver City (KAM).

HABITAT

Both Banff records were from open, grassy areas in the montane ecoregion.

MOUNTAIN BLUEBIRD *Sialia currucoides* **(B)** **MOBL**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

The Mountain Bluebird breeds in western North America from Alaska across to southern Manitoba and south to California and New Mexico (Godfrey 1966). It nests in south and central Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from mid March to late May, peaking in early April. The earliest record is 16 February 1914 in Banff (Clarke and Cowan 1945); the earliest recent record is a male on 17 March 1979 at Vermilion Lakes (McIvor and McIvor 1980). The maximum count was at least 20 on 15 April 1979 at Vermilion Lakes (McIvor and McIvor 1980). It usually occurs in small flocks of 4 to 6 birds.

In the summer it occurs throughout most of Banff and Jasper. There are several nest records from both parks, the earliest being a nest with eggs found on 26 May

1946 near Edith Lake (Cowan 1955). The earliest fledged young were seen on 23 June 1978 in the lower North Saskatchewan River valley (MJD). Flocks are sometimes seen in summer; the largest was 16 birds on 14 June 1979 in the lower Red Deer River valley.

Autumn migration occurs in September and early October. The latest record is a male and two females seen on 5 November 1976 at Windy Point in the lower Athabasca River valley. The maximum count was a flock of at least 25 birds on 2 September 1979 in the lower Cascade River valley (McIvor and McIvor 1980). Flocks of up to 20 birds are not unusual.

The Mountain Bluebird is evidently less common now than in years past. Clarke and Cowan (1945) considered it "common" throughout Banff. In Jasper, between Jasper townsite and the East Gate, Cowan (1955) cites two nests and mentions "several other nests in the mid 1940's." Banfield recorded 9 birds in June 1946 (Jasper warden cards); there are no records since then of Mountain Bluebirds in the lower Athabasca River valley during the breeding season.

HABITAT

The Mountain Bluebird occurs primarily in the upper subalpine ecoregion, but is also found in the lower subalpine and montane ecoregions. It inhabits open forests (especially Engelmann spruce–subalpine fir), forest edges and burntlands. It nests in tree cavities and crevices in cliffs.

During the breeding season only open subalpine larch/heath forest forest supports a moderate density of Mountain Bluebirds (DI=6.42).

MANAGEMENT CONSIDERATIONS

Removal of dead trees for firewood or other purposes decreases the already-limited supply of nest sites for Mountain Bluebirds and other hole-nesting species.

Nest boxes properly located will be used by bluebirds which are subject to heavy competition for nest sites by starlings and swallows. A bluebird trail of nest boxes was established in logging areas adjacent to Jasper National Park in 1976 (Carter 1979). Occupancy by both the Mountain Bluebird and Tree Swallow increased dramatically each year for the three years reported.

TOWNSEND'S SOLITAIRE *Myadestes townsendi* **(B)** **TOSO**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: common resident
Autumn: uncommon migrant
Winter: rare resident

Townsend's Solitaire breeds in western North America between the west coast and Rocky Mountains from Alaska to northern Mexico (Godfrey 1966). In Alberta, it nests throughout the Rockies and their foothills (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from early April to late May, peaking in late April and early May. One or two early migrants are regularly seen in Banff in March. The earliest Jasper record is 3 April 1941 at Blue Creek (Cowan 1955). The maximum count was 26 on 4 May 1976 near the lower Maligne River. It is usually encountered in small groups of up to five.

In the summer it occurs throughout both parks. There are four Banff and two Jasper nest records, the earliest being a nest with 1 egg on 4 June 1946 near Banff townsite (Ashley, Banff warden card). On 9 June 1944 "a nest full of young" was found on Mount Bourgeau (Cowan 1955). The earliest fledged young was seen on 19 July 1977 in the upper North Saskatchewan River valley (JDS). This is one of the common summer thrushes.

Autumn migration occurs in late August and September, after which only the occasional bird is seen. The latest Jasper record is one on 9 November 1978 in the lower Athabasca River valley (JLK). The maximum count is a flock of ten on 25 August 1978 in the upper North Saskatchewan River valley.

In the winter it does not occur in Jasper. However, it is recorded regularly in late December on Banff Christmas Bird Counts, with a high count of thirteen in 1977. There are at least 5 records in each of January and February in the lower Bow River valley, mainly near Banff townsite and the lower Spray River. Probably a few birds remain the entire winter, particularly during mild winters.

HABITAT

Townsend's Solitaire occurs primarily in the lower and upper subalpine ecoregions but also regularly in the montane ecoregion. Although it inhabits all types of coniferous forest, it prefers open forests, forest margins and timberline areas, always on sloping terrain.

It is often found in open forests along steep slopes where small cliffs provide nesting sites. It nests on the ground, usually under a protective overhang on a cliff or cutbank. Road cuts are readily used for nesting.

The highest densities of Townsend's Solitaires during the breeding season are in Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (04) forest (DI=7.71), subalpine fir-willow (S2) avalanche slopes (DI=4.80), hairy wild rye-junegrass-bearberry (H14) slopes (DI=4.74), open subalpine larch/heath forest (DI=3.74), white spruce/juniper/bearberry (017) forest (DI=3.43) and Engelmann spruce-subalpine fir/heather (010) timberline forest (DI=3.39).

In winter Townsend's Solitaires occur in Douglas-fir forests in the montane ecoregion.

GOLDEN-CROWNED KINGLET *Regulus satrapa* **(b)** GOKI

STATUS AND DISTRIBUTION

Spring: common resident
Summer: very common resident
Autumn: common resident
Winter: uncommon resident

The Golden-crowned Kinglet occurs throughout most of North America. It breeds throughout the northern half of Alberta and in the Rocky Mountains (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from late March to early May, peaking in late April. The maximum count was 18 on 23 April 1977 in the lower Maligne River valley. It is usually encountered singly or in small groups of up to ten, occasionally in loose association with chickadee flocks.

In the summer it occurs throughout both parks. There are no nest records. In Banff, adults have been seen carrying food, presumably to young, on two occasions, the earlier being on 3 July 1979 in the Panther River valley (HFC). Also, fledged young have been seen on several occasions in Banff, the earliest being on 14 July 1977 in the Alexandra River valley (DJK).

Autumn migration occurs from late August to early October, with occasional later stragglers. The maximum count was 33 on 19 September 1977 near Jasper townsite. Although usually in small groups flocks of up to twenty have been recorded.

In the winter, small numbers remain in both parks, with up to four having been recorded on any one occasion. It is most common in lower valleys, and sometimes occurs in the company of chickadees and nuthatches.

HABITAT

The Golden-crowned Kinglet occurs primarily in the lower subalpine ecoregion, but is also found in the montane and upper subalpine. It inhabits coniferous forests of all types, but prefers closed Engelmann spruce-subalpine fir and lodgepole pine-spruce forests.

During the breeding season highest densities are found in Engelmann spruce-subalpine fir/false azalea (C14) (DI=29.30), white spruce/prickly rose/horsetail (C4) (DI=28.14), lodgepole pine/feathermoss (C11) (DI=24.30), and Engelmann spruce-subalpine fir/feathermoss (C13) forest (DI=19.47).

Of 19 Golden-crowned Kinglets recorded during winter transects, 10 were in Engelmann spruce-subalpine fir or lodgepole pine-spruce forest, and none were in lodgepole pine.

RUBY-CROWNED KINGLET *Regulus calendula* **(B)** **RUKI**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: very common resident
Autumn: common migrant
Winter: not recorded

The Ruby-crowned Kinglet breeds across North America from treeline south to California and the northeastern United States (Godfrey 1966). It nests throughout forested northern and western Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from mid April to late May, peaking in late April and early May. The earliest record is a singing male on 9 April 1941 in the lower Athabasca River valley (Cowan 1955). The maximum count was 40 birds on 29 April 1977 along the middle Athabasca River valley. Usually only one to three are encountered, but flocks of up to 20 are not unusual. The Ruby-crowned Kinglet is one of the more common spring migrants.

In the summer it occurs throughout both parks. There is one nest record for each park, a nest found on 24 June 1975 in the upper Bow River valley (JWW), and one with nestlings found on 25 July 1944 at Maligne Lake (Cowan 1955). Fledged young were first seen on 28 July 1979 in the upper Red Deer River valley (KAM).

Autumn migration occurs from mid August to early October, peaking in mid September. The latest record of one on 11 October 1977, and the maximum count of 41 on 19 September 1977, occurred near Jasper townsite.

There are two winter records: one was recorded in a flock of chickadees on 7 January 1979 along the upper Miette River (KVT), and one was recorded on 6 March 1980 in the middle Bow River valley (GLH).

HABITAT

The Ruby-crowned Kinglet occurs from the montane to the upper subalpine ecoregion. It inhabits all types of mature coniferous forest, but is most common in stands having a large proportion of spruce and numerous dead or dying trees. Such stands occur on alluvial sites, at timberline, on avalanche slopes and at the edges of burned areas.

During the breeding season the highest densities of Ruby-crowned Kinglets are found in white spruce/shrubby cinquefoil/bearberry (O3) forest (DI=17.56), black spruce-lodgepole pine/willow/sedge (C8) forest (DI=15.61), white spruce/prickly rose/horsetail (C4) forest (DI=14.79) and lodgepole pine/green alder/feathermoss (C10) forest (DI=10.73).

WATER PIPIT *Anthus spinoletta* **(B)** **WAPI**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: very common resident
Autumn: common migrant
Winter: not recorded

The Water Pipit breeds in the tundra and mountains of Eurasia and North America, occurring in the mountains of North America from Alaska south to New Mexico (Godfrey 1966). In Alberta, it nests in the Rocky Mountains (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from late April to early June, peaking in early to mid May. The earliest record is 12 birds on 19 April 1976 at Vermilion Lakes (McIvor and McIvor 1980). An unusually high maximum count of 162 birds was recorded on 12 May 1977 along the lower Maligne River valley; other counts were less than half this number. It usually occurs in flocks of up to 40 birds.

In the summer, it occurs at high elevations throughout both parks. There are numerous Banff and Jasper nest records, the earliest being a nest with 5 eggs found on 18 June 1976 at Wilcox Pass (JRS). Nestlings were found between 5 July 1976 on Signal Mountain (A. Strepniewski) and 20 July 1979 in the Restless River watershed (KVT). The earliest fledged young were seen on 21 July 1976 in the Sunwapta River drainage (DJK).

Autumn migration occurs from early August, when flocks begin forming, to early October. The latest record is a flock of 15 on 13 November 1978 in Tonquin Valley. The maximum count is a flock of 100 on 7 September 1976 in the Mistaya River valley. Autumn Water Pipit flocks are of varying size, but rarely exceed 40.

HABITAT

The Water Pipit occurs in the upper subalpine and alpine ecoregions, except during migration. It inhabits a wide variety of open habitats, from wetlands to fairly dry tundra, with highest densities during the breeding season being found on mountain avens–snow willow–moss campion (H1) tundra (DI=24.55), heather–everlasting (L5) meadows (DI=22.81) and mountain marigold–globeflower (H9) meadows (DI=19.23).

In migration it occurs along river flats and roadsides and other open areas in the lower subalpine and montane ecoregions.

SPRAGUES'S PIPIT *Anthus spragueii* **SPPI**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare visitor
Winter: not recorded

Sprague's pipit breeds in central North America from the central prairie provinces south to Montana and western Minnesota (Godfrey 1966). It nests locally in the southern two–thirds of Alberta west to the foothills (Salt and Salt 1976).

There are no Banff records. There is one Jasper record, supported by photographic evidence, of two on Wilcox Pass on 9 August 1978 (T.E. Goldsmith, pers. comm.). Clarke and Cowan (1945) found Sprague's pipits at the Ya–ha–tinda Ranch adjacent to Banff but there are no records of the species in grassland areas of Banff and Jasper where it might be expected to occur.

HABITAT

Sprague's pipit inhabits "prairie grasslands and short–grass plains" (Godfrey 1966). The Wilcox Pass record must be considered extremely anomalous.

BOHEMIAN WAXWING *Bombycilla garrulus* **(b?)** **BOWA**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: fairly common resident
Autumn: very common migrant
Winter: fairly common resident

The Bohemian Waxwing breeds in northwestern North America from Alaska and Manitoba south to Washington and Idaho; it also breeds widely in Eurasia (Godfrey 1966). It nests in the northern half of Alberta and, presumably, in the Rockies and their foothills south to Banff (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from early March to early May, peaking in early April. The maximum count is 1439 on 6 April 1978 along the middle Bow River valley; counts are usually of fewer than 100 birds. On 2 April 1978 at least 1000 were seen at Vermilion Lakes (McIvor and McIvor 1980), and flocks of at least 300 have been recorded several times between mid April and early May in the Bow River

valley.

In the summer it occurs throughout Jasper and in the Alexandra and Howse River valleys of Banff. It is most common in the Athabasca River watershed. It is usually seen singly or in groups of fewer than ten. There are no nest records. The only evidence of breeding is an adult seen carrying nesting material on 6 July 1976 in the Whirlpool River watershed (DJK).

Autumn migration occurs from late August to late October, with influxes throughout this period. The maximum count is 1000 on 13 October 1971 in the lower Bow River valley at the hoodoos (Gordon 1975). Survey counts of over 100 were not unusual, with the maximum being 611 on 17 October 1977 near Banff townsite. Flocks usually consist of 10 to 70; the largest recorded single flock was about 250 on 30 October 1979 along the middle Cascade River (RLM).

In the winter, it occurs in many lower valleys of both parks. It is most common in the lower Bow River and lower and middle Athabasca River valleys where flocks of up to 75 are regularly recorded. The maximum count was at least 100 birds on 2 February 1975 at Vermilion Lakes (McIvor and McIvor 1980).

The Bohemian Waxwing may formerly have been a more common summer resident in Banff, for Clarke and Cowan (1945) considered it to be "common and widely distributed".

HABITAT

The Bohemian Waxwing occurs mainly in the montane ecoregion, particularly in the winter, but is also regularly found in the lower and upper subalpine ecoregions. It inhabits open coniferous forests, often adjacent to streams, lakes and boggy areas. In winter it frequents townsites and sunny montane slopes with bearberry and juniper mats.

CEDAR WAXWING *Bombycilla cedrorum* **(b)** **CEWA**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

The Cedar Waxwing breeds across North America from northern Canada south to California and Georgia (Godfrey 1966). It nests throughout Alberta except in the extreme north (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in June; few are seen before this month. The earliest certain record is 4 May 1973 at Banff townsite (Gordon 1975). The largest flocks recorded consisted of only five.

In the summer this species has been recorded in several valleys throughout both parks, and most commonly in the lower Bow and Athabasca River valleys. The maximum count is 8 on July 1979 at Vermilion Lakes (McIvor and McIvor 1980). There are no nest records. The only evidence that they may breed in the parks is a record of adults seen feeding immature birds at Vermilion Lakes on 23 August 1979 (McIvor and McIvor 1980).

Autumn migration occurs from mid August to late September. The latest record is a flock of five on 23 September 1979 at Meadow Creek. The maximum count is a flock of 16 on 28 August 1977 near Jasper townsite.

Clarke and Cowan (1945) considered it "common... throughout Banff". In Jasper in the lower Athabasca River valley it was considered "common" at the turn of the century, but "was not abundant in 1944" (Clarke 1955).

HABITAT

The Cedar Waxwing occurs in the montane and, to a lesser extent, lower subalpine ecoregions. It frequents forest edges and deciduous woods and shrubbery, often near water.

NORTHERN SHRIKE *Lanius excubitor* **NOSH**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: not recorded
Autumn: very rare migrant
Winter: rare visitor

The Northern Shrike breeds in Eurasia, northern Africa and across northern North America just south of treeline; it winters in southern Canada and the northern United States (Godfrey 1966). It is a migrant through Alberta, nesting in the extreme northeast and wintering in small numbers from about Calgary southwards (Salt and Salt 1976).

In Banff and Jasper it is a migrant, and may occasionally winter in the lower Bow River valley. Autumn records for Banff include 10 individuals seen on 2 August 1977 in the upper Bow River valley, and 6 on 15 August 1977 at Healy Creek. There is only one autumn record of this species in Jasper, one seen on 3 October 1978 in the lower Athabasca River valley (KVT).

There are two winter records: one was seen on 22 January 1976 in the lower Bow River valley (DJK), and one was recorded on 25 February 1969 at Banff townsite (Gordon 1975).

Spring migration begins in late March and lasts until mid May. One Northern Shrike was seen on 30 March 1980 in the lower Athabasca River valley; all other spring observations are from the lower Bow River valley. Although 17 shrikes were seen on 6 May and eight on 12 May 1977 along the lower Bow River, most records are of fewer than 4. The latest record is 12 May 1977.

HABITAT

The Northern Shrike occurs primarily in the montane ecoregion, but on migration has been recorded rarely as high as the upper subalpine ecoregion. It inhabits shrubby wetlands and grasslands.

COMMON STARLING *Sturnus vulgaris* **(B)** **STAR**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: uncommon resident
Autumn: fairly common migrant
Winter: uncommon resident

The Common Starling, a Eurasian species, was introduced into North America in 1890 and now breeds across southern Canada and in much of the United States (Godfrey 1966). It was first recorded in Alberta in 1934, and now nests throughout the province (Salt and Salt 1976).

The Starling is a permanent resident of Banff and Jasper, occurring almost exclusively in the lower and middle Bow River, and lower and middle Athabasca River valleys. In June, 2 or 3 birds have also been recorded in the Miette and upper North Saskatchewan River valleys. The maximum summer count was 30 birds on 27 June 1975 at the Banff landfill site. The maximum winter count was 35 birds on 5 March 1977 at the Jasper sanitary landfill. In winter Common Starlings are confined to townsite areas. Up to 28 have been recorded on Banff Christmas Bird Counts.

There is some migration of starlings through the parks in spring and autumn; at these times they may be seen at any location. Spring migration occurs from late March to late May, peaking in April. The maximum count was at least 150 on 7 April 1979 at Vermilion Lakes (McIvor 1980); most counts are of less than 50 birds. Autumn migration occurs in September and October, peaking in early October. The maximum autumn count is 75 on 9 October 1977 at Banff townsite.

There are no Jasper nest records. There are several for Banff, the earliest being a nest with nestlings found on 3 June 1977 in the lower Bow River valley (GLH). The earliest record of fledged young is 5 June 1977 at Vermilion Lakes (McIvor and McIvor 1980).

There are no records of the Common Starling given for Banff by Clarke and Cowan (1945), nor for Jasper by Cowan (1955). In Banff, the first year it was recorded is 1948: one was seen on 20 and 22 March in Banff townsite, and 2 flocks of about 60 birds in total were seen on 15 August at the Buffalo Paddock outside Banff townsite for about two weeks (BNP warden cards). There are no records of the Common Starling in Jasper previous to this inventory, although undoubtedly it was present. The first year it was recorded in Jasper is 1975, when 2 to 12 birds were recorded in April, August and September.

HABITAT

The Common Starling occurs in the montane and lower subalpine ecoregions. It inhabits deciduous or mixed deciduous/coniferous forests, forest edges, wetlands and townsites. It is most commonly seen in townsites, at landfill sites and along roadsides, particularly on migration.

SOLITARY VIREO *Vireo solitarius* **(b)** **SOVI**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

The Solitary Vireo breeds across North America from southern Mackenzie and Nova Scotia south to Michigan and, in the mountains, to El Salvador (Godfrey 1966). It breeds in northern and central Alberta and in the mountains (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in May and early June, peaking in late May. The earliest record was one on 7 May 1977 and the maximum count was seven on 27 May 1977, both in the middle Bow River valley.

In the summer, it has been recorded in numerous valleys throughout both parks, but has not been recorded in Jasper north of the Miette and lower Athabasca Rivers. It is most common in the lower and middle Bow River and lower Athabasca River valleys. There are no nest records.

Autumn migration lasts from early August to mid September. The latest record is one on 15 September 1979 in the lower Cascade River drainage. The maximum count was three on 9 August 1977 in the upper Athabasca River valley.

The Solitary Vireo was not recorded in Banff by Clarke and Cowan (1945) or in Jasper by Cowan (1955), although both workers visited areas where the species is now present.

HABITAT

The Solitary Vireo occurs primarily in the montane ecoregion, but is also found in the lower subalpine. It inhabits coniferous forests, particularly spruce and pine stands with intermixed deciduous trees and shrubbery. Out of 49 Solitary Vireos recorded on call-count transects, 29 were in lodgepole pine-dominated forests, but the highest density recorded was in white spruce/prickly rose/horsetail (C4) forest (DI=3.74, n=4).

RED-EYED VIREO *Vireo olivaceus* **(b)** **REVI**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: rare resident
Autumn: rare migrant
Winter: not recorded

The Red-eyed Vireo breeds across North America from the southern half of Canada south to northern parts of the United States (Godfrey 1966). It nests throughout Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in late May and early June. The earliest record is on 19 May 1944 in the lower Snake Indian River valley (Cowan 1955).

No more than one has been recorded on any one occasion.

All recent summer records are from the lower and middle Bow River. This includes 17 recorded since 1975, at least 9 of these being singing males. On 3 July 1943 a singing male was seen at Windy Cabin in the Panther River valley (Clarke & Cowan 1945). In Jasper, 3 were seen on 27 June 1944 and several in June 1946 near Jasper townsite (Cowan 1955) but the species is now of only rare and sporadic occurrence in the lower Athabasca River valley.

There are three autumn records: four were seen on 2 September 1978 near Banff townsite (McIvor and McIvor 1980), two were heard on 15 September 1979 in the lower Cascade River valley (GLH), and one was seen in a flock of migrating warblers on 2 September 1979 in the lower Athabasca River valley (KVT).

HABITAT

The Red-eyed Vireo inhabits montane deciduous forests and shrubbery.

PHILADELPHIA VIREO *Vireo philadelphicus* **PHVI**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: not recorded
Autumn: very rare visitor
Winter: not recorded

The Philadelphia Vireo breeds in the southern half of Canada east of the Rockies, and in the northeastern United States (Godfrey 1966). It nests in northern and east-central Alberta (Salt and Salt 1976).

There are no Banff records. There are two Jasper records: one was seen on 21 May 1978 in the middle Athabasca River valley and one on 27 August 1978 in the lower Athabasca River valley.

HABITAT

The Philadelphia Vireo occurs in "... open mixed and deciduous woodland, wood edges, aspen parklands, second growth on burntlands and logged areas, (and) thickets of alder and willow." (Godfrey 1966). Both Jasper records were in alluvial willow stands in the montane ecoregion.

WARBLING VIREO *Vireo gilvus* **(b)** **WAVI**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: common resident
Autumn: uncommon migrant
Winter: not recorded

The Warbling Vireo breeds across North America from southwestern Mackenzie in the west and southern Ontario in the east, south to northern Mexico (Godfrey 1966). It nests throughout Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from early May to early June, peaking in late May and early June. The earliest record is 3 May 1977 and the maximum count is 19 on 2 June 1977 in the middle Bow River valley. Most records are of single birds and pairs.

The Warbling Vireo is the commonest vireo in Banff and Jasper in spring and summer, being most common in the lower and middle Bow River, Athabasca River and Miette River valleys. There are no records from Jasper north of the Miette and lower Athabasca Rivers although it likely occurs along the Snake Indian River. There are no nest records; however a pair was seem carrying food, presumably to young, on 12 July 1979 along the lower Bow River (HFC). Fledged young were seen on 9 August 1939 in the lower Spray River valley (Clarke and Cowan 1945).

Autumn migration occurs in August. The latest record is 28 August 1977, and the maximum count is 12 on 15 August 1977, both near Jasper townsite. Usually only one or two are encountered, usually in mixed flocks of other migrant passerines.

HABITAT

The Warbling Vireo occurs almost exclusively in the montane ecoregion; the occasional bird is encountered in the lower subalpine. It inhabits deciduous woodland and, to a lesser extent, mixed deciduous/coniferous forest, particularly on alluvial fans and floodplains. Shrubby avalanche slopes are also used by Warbling Vireos.

The highest densities of Warbling Vireos during the breeding season are in aspen/hairy wild rye-peavine (C16) forest (DI=22.91), aspen-lodgepole pine forest (DI=12.66), Douglas fir/hairy wild rye (C1) forest (DI=5.36) and subalpine fir-willow (S2) avalanche slopes (DI=3.80).

BLACK AND WHITE WARBLER *Mniotilta varia* **BWWA**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Black and White Warbler breeds in central and eastern North America east of the Rockies, including most of temperate Canada and the United States (Godfrey 1966). It breeds in northern and central Alberta, excluding the Rockies (Salt and Salt 1976).

There are two Banff and two Jasper records of this species. In the lower Athabasca River valley one was recorded on 21 May 1976 (GLH), and a male was seen on 28 May 1978 (DJH). In the lower Bow River valley, one was seen on 30 May 1974 (Gordon 1975) and one on 9 June 1975 (JWW).

HABITAT

The Black and White Warbler inhabits "deciduous and mixed woodlands of various types, especially in moister situations" (Godfrey 1966). All Banff and Jasper records were in the montane ecoregion.

TENNESSEE WARBLER *Vermivora peregrina* **(b)** **TEWA**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

The Tennessee Warbler breeds across most of forested Canada and in the northern U.S.A. east of the Rockies (Godfrey 1966). It breeds throughout Alberta except in the southern prairies (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in mid and late May. The earliest record is 12 May 1974 at Banff townsite (Gordon 1975). The maximum count is six on 19 May 1976 in the lower Athabasca River valley.

In the summer it probably occurs throughout both parks. It was recorded throughout most of the Bow and Athabasca valleys, and in the Mistaya River, lower North Saskatchewan River, Miette River and Whirlpool River valleys, but was not common at any location. There are no nest records. An adult was seen carrying food, presumably to young, on 10 July 1978 in the lower North Saskatchewan River valley (MJD).

Autumn migration occurs in August and early September. The latest record is three on 6 September 1978 in the lower Athabasca River valley. The maximum count is four on 2 September 1977 near Banff townsite.

Apparently this species was formerly more common in Jasper than at present. Cowan (1955) states that "... in 1944, 1945, and 1946 it was found to be one of the most abundant warblers in the Athabasca Valley. On June 15, 1944, 20 singing males

were tallied between Snaring and Pocohontas."

HABITAT

The Tennessee Warbler occurs in forested wetlands of the montane and lower subalpine ecoregions. It inhabits spruce forest, open deciduous or mixed deciduous/ coniferous forest, and willow or alder thickets.

ORANGE-CROWNED WARBLER *Vermivora celata* **(b)** **ORWA**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: common resident
Autumn: uncommon migrant
Winter: not recorded

The Orange-crowned Warbler breeds across North America from Alaska and much of forested Canada south to Baja California and Texas (Godfrey 1966). It breeds locally throughout northern and central Alberta and in the Rocky Mountains (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in May, peaking in mid May. The earliest record is 28 April 1979 in the lower Athabasca River valley. The maximum count is 14 birds on 19 May 1978 in the middle Bow River valley. This species is one of the earliest and most common warbler migrants.

In the summer it occurs throughout both parks; it is most common in the middle Bow River and lower Athabasca River valleys. There are no nest records.

Autumn migration is from mid August to late September, peaking in late August. The latest record is 28 September 1977 near Banff townsite. The maximum count is six on 15 August 1977 near Jasper townsite.

HABITAT

The Orange-crowned Warbler occurs primarily in the montane and lower subalpine ecoregions, but is occasionally encountered in the upper subalpine ecoregion. It inhabits wetlands with deciduous or mixed deciduous/white spruce forest or tall willow and alder shrubbery. In the subalpine ecoregion it may be found in subalpine fir krummholz and shrubby avalanche slopes.

During the breeding season the highest densities of Orange-crowned Warblers are in white spruce/prickly rose/horsetail (C4) forest edges (DI=8.24), aspen/hairy wild rye-peavine (C16) forest (DI=6.34), dwarf birch-shrubby cinquefoil/needlerush (S3) wetlands (DI=5.77) and subalpine fir-willow (S2) avalanche slopes (DI=5.74).

NASHVILLE WARBLER *Vermivora ruficapilla* **NAWA**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: not recorded
Autumn: very rare migrant
Winter: not recorded

The Nashville Warbler breeds across North America from southern Canada (in British Columbia and from Manitoba eastward) south to California and northeastern United States (Godfrey 1966). There are only a few records of its occurrence in Alberta, most of these since 1967 (Salt and Salt 1976).

There are no Jasper records. There are four Banff records of this warbler, all from the Banff townsite-Vermilion Lakes area. In the spring, a pair was seen on 30 April 1968, and one was seen on 12 May 1974 (Gordon 1975). In the autumn, one bird was seen on 1 August and one on 3 September 1968 (Salt and Salt 1976).

HABITAT

The Nashville Warbler inhabits "sparse, immature deciduous or mixed woods, especially where aspen or birch are a component, with low bushes, on either dry or moist land: (including) second growths on old clearings, burntlands (and) sparsely treed bogs" (Godfrey 1966). All Banff records were in the montane ecoregion.

YELLOW WARBLER *Dendroica petechia* **(B)** **YEWA**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: fairly common resident
Autumn: uncommon migrant
Winter: not recorded

The Yellow Warbler breeds in North and South America from Alaska south to Peru and Venezuela (Godfrey 1966). It nests throughout Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in late April and May. The earliest record is four on 23 April 1977 in the lower Maligne River valley. The highest count is 15 on 19 May 1977 near the lower Bow River. It is usually encountered singly or in pairs.

In the summer it is most common along the lower and middle Bow River, Miette River, and Athabasca River valleys. One or two have been recorded in only a few other valleys at scattered locations. There are two Jasper nest records, the earlier being a nest with 4 eggs found on 5 July 1976 near the Miette River (DMI). On 6 July 1955 a fledged young was seen with adults in the lower Bow River valley (DJK).

Autumn migration occurs from August to mid September. The latest record on 10 September 1977 and the maximum count of five on 8 and 15 August were both in the Banff townsite area.

HABITAT

The Yellow Warbler occurs in the montane and, to a lesser extent, lower subalpine ecoregions. It inhabits wet deciduous shrubby meadows, and shrubby avalanche slopes and burntlands at low elevations.

The only habitat supporting a high density of Yellow Warblers during the breeding season is dwarf birch-shrubby cinquefoil/needlerush (S3) wetland (DI=13.07).

MAGNOLIA WARBLER *Dendroica magnolia* **(b?)** **MAWA**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: rare resident
Autumn: very rare migrant
Winter: not recorded

The Magnolia Warbler breeds almost across North America, from southwestern Mackenzie to Newfoundland and south to central British Columbia and the northeastern United States (Godfrey 1966). It breeds in the northern half of Alberta "and, in the Rocky Mountains, south to the Banff area" (Salt and Salt 1976).

There are only two Jasper spring records, a male seen on 21 May 1977 in the lower Athabasca River valley (JDS), and two males seen on 28 and 31 May 1944 at Blue Creek (Cowan 1955). There are five Banff spring records including one on 25 April 1975 (McIvor and McIvor 1980) and 30 May 1965 (Gordon 1975) at Vermilion Lakes, and one on 28 May 1953 (Banfield 1954a) and 28 May 1978 and four on 30 May 1976 (McIvor and McIvor 1980).

There are several summer records. For Banff these include: one on 2 and 29 June 1979 (McIvor and McIvor 1980) and one on 4 June 1977 (D. Brunton, pers. comm.) at Banff townsite, two singing males on 7 June 1979 in the lower Cascade River valley (KAM), and a singing male on 7 June 1978 (KAM) and 19 June 1977 (JRS) in the upper North Saskatchewan River valley. There is only one recent Jasper record, one seen on 6 June 1979 in the lower Athabasca River valley (DJH). In June 1946, at least three were recorded in the lower and middle Athabasca River valleys (Banfield, Jasper warden cards and Cowan 1955). There are no nest records.

There is one autumn record, on 19 September 1975 in the middle Bow River valley (DJK).

HABITAT

The Magnolia Warbler occurs in open coniferous and mixed wood forests of the montane and lower subalpine ecoregions.

CAPE MAY WARBLER *Dendroica tigrina* **CMWA**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Cape May warbler breeds in North America east of the Rockies from Alberta and southern Mackenzie to Nova Scotia and south to the extreme northeastern United States (Godfrey 1966). It breeds locally in northern Alberta (Salt and Salt 1976).

There is one Banff record of this warbler: a singing male was observed at Banff townsite from 29 May until 5 June 1981 (KVT, GLH, RM, Wershler). There are two summer records for Jasper, both from the lower Athabasca River valley. A singing male was seen on 3 June 1946 (Cowan 1955), and one was recorded on 13 June 1946 at Pocahontas (Banfield, Jasper warden cards).

HABITAT

The Cape May warbler inhabits "coniferous woods and mixed woods, especially more open types and edges" (Godfrey 1966). The Jasper records are from montane white spruce forests. The Banff bird was in montane mixed aspen/white spruce.

YELLOW-RUMPED WARBLER *Dendroica coronata* **(B)** **YRWA**

STATUS AND DISTRIBUTION

Spring: very common migrant
Summer: abundant resident
Autumn: common migrant
Winter: not recorded

The Yellow-rumped Warbler breeds across North America in coniferous forests from near treeline in Alaska and Canada south to northern Mexico and the northeastern United States (Godfrey 1966). It breeds in north, central, and southwest Alberta to the prairies (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from late April to late May, peaking in mid and late May. The earliest record is 26 April 1978 near Bankhead in Banff. The maximum count is 92 on 21 May 1976 along the middle Athabasca River. It is usually encountered singly or in small flocks of up to 5 birds, although occasionally larger groups are seen. It is by far the most common spring warbler, and is also one of the most common migrants overall.

In the summer it is ubiquitous in both parks. Despite the abundance of this species, there are surprisingly few nest records. There are none for Jasper, although a pair was seen carrying nest material on 17 May 1944 in the lower Athabasca River valley (Cowan 1955). There are two records for Banff: on 6 June 1979 a pair was seen building a nest in the lower Cascade River valley (HFC), and on 11 July 1977 a nest with 4 young was found in the upper Spray River valley (MED). The earliest sighting of fledged young "...just out of the nest..." was on 26 June 1944 in the lower Athabasca River valley (Cowan 1955). There are observations of adults carrying food, presumably to

young, from late June to early August. The Yellow-rumped Warbler is the most common warbler, and is one of the most common breeding birds, in Banff and Jasper.

Autumn migration occurs from August to early October, peaking in late August and early September. The latest record is 17 October 1978 in the lower Bow River valley. The maximum counts of 53 and 46 birds were on 7 and 28 August 1977, respectively, near Jasper townsite. Between 19 and 21 August 1943 over 150 were counted at Blue Creek (Cowan 1955). It is usually encountered in small flocks of up to twenty. It is the most common autumn warbler, and is also one of the most common migrants overall.

HABITAT

The Yellow-rumped Warbler inhabits woodland from the montane to the upper subalpine ecoregion. It is very common in almost all types of woodland.

During the breeding season, highest densities of Yellow-rumped Warblers are in the following forest types:

Douglas fir/hairy wild rye (C1) forest	(DI=29.10)
lodgepole pine/juniper/bearberry (C3) forest	(DI=24.32)
lodgepole pine/buffaloberry/showy aster (C6) forest	(DI=19.69)
lodgepole pine/buffaloberry/grouseberry (C18) forest	(DI=23.69)
lodgepole pine/buffaloberry/twinflower (C19) forest	(DI=23.33)
lodgepole pine/false azalea/grouseberry (C20) forest	(DI=20.46)
white spruce/buffaloberry/fern moss (C26) forest	(DI=22.64)
lodgepole pine/Labrador tea (C29) forest	(DI=20.13)
Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31) forest	(DI=21.43)
aspen-lodgepole pine forest	(DI=21.01)
Open aspen forest	(DI=29.67)
Open white spruce/shrubby cinquefoil/bearberry (O3) forest	(DI=21.43)
Open white spruce/juniper/bearberry (O17) forest	(DI=20.31)
lodgepole pine savannah(H6 and C3)	(DI=21.19)

TOWNSEND'S WARBLER *Dendroica townsendi* **(b)** **TOWA**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: very common resident
Autumn: fairly common migrant
Winter: not recorded

Townsend's Warbler breeds in western North America from the Rockies westward, and from Alaska to Wyoming (Godfrey 1966). It nests in southwestern Alberta in the Rocky Mountains (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in May and early June, peaking in late May. The earliest record is one on 6 May 1979 in the lower Athabasca River valley. The maximum is 16 on 2 June 1977 in the middle Bow River valley. It is usually encountered in small groups of one to five, and is one of the most common spring warblers.

In the summer it occurs throughout both parks. North of the Miette and lower Athabasca Rivers it has only been recorded in the Smoky River drainage (KAM). It is

distinctly more common in the valleys of the Main Ranges, and appears to be particularly common in the middle Bow River watershed. Although it undoubtedly breeds, there are no nest records. A pair with a fledged young was seen on 1 August 1975 in the upper Bow River valley (DJK). Townsend's Warbler is one of the most common warblers in summer.

Autumn migration occurs in August, peaking in mid August. The latest record is 8 September 1917 (Taverner, in Clarke and Cowan 1955) and the maximum count is twenty on 15 August 1977, both near Banff townsite. It is encounterd singly or in flocks of up to 20 birds, and is one of the most common autumn warblers.

HABITAT

Townsend's Warbler occurs in the montane, lower subalpine and, to a limited extent, upper subalpine ecoregions. It inhabits closed, moist coniferous forests, particularly white spruce or Engelmann spruce-subalpine fir, and is uncommon in pine forest. The highest densities of Townsend's Warblers during the breeding season are in white spruce/prickly rose/horsetail (C4) forest (DI=27.71), Engelmann spruce-subalpine fir/ false azalea (C14) forest (DI=16.32), and lodgepole pine/feathermoss (C11) forest (DI=12.31).

BLACK-THROATED GREEN WARBLER *Dendroica virens* **BGWA**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: not recorded
Autumn: not recorded
Winter: not recorded

The Black-throated Green Warbler breeds in North America from northern Alberta eastward across southern Canada and the northeastern United States (Godfrey 1966). It nests in much of the northern half of Alberta (Salt and Salt 1976).

There are no Jasper records. There is one Banff record, a male on 28 April 1977 at Vermilion Lakes (Bow Valley Naturalists 1978).

HABITAT

The Black-throated Green Warbler inhabits "... more open coniferous and mixedwoods" (Godfrey 1966) where spruce predominates (Salt 1973). The Banff observation was in a dense, mature white spruce forest in the montane ecoregion.

BLACK-THROATED GRAY WARBLER *Dendroica nigrescens*

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare visitor
Winter: not recorded

The Black-throated Gray Warbler breeds in western North America from southwest British Columbia and central Colorado south in the mountains to Baja California (Godfrey 1966). It is considered hypothetical in Alberta due to lack of material evidence of its occurence (Salt and Salt 1976).

There are no Jasper records. In Banff one was reported on 30 August 1970 at the Vermilion Lakes (American Birds 1971, Vol. 25, p 83).

BAY-BREASTED WARBLER *Dendroica castanea* **BAWA**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: very rare visitor
Winter: not recorded

The Bay-breasted Warbler breeds in North America from about northern Alberta across southern Canada to Nova Scotia and the extreme northeastern United States (Godfrey 1966). It nests in northeast and northcentral Alberta, "... south to Peers and Jasper" (Salt and Salt 1976).

There is only one unsubstantiated record of this species for Banff, on 30 May 1977. In Jasper there is one summer and one autumn record. On 6 June 1946, a male was seen at Pyramid Lake (Cowan 1955). On 15 August 1977 one was recorded near Jasper townsite (DJK).

HABITAT

The Bay-breasted Warbler inhabits "... coniferous woods, often with an admixture of deciduous trees; wood edges and openings; (and) second growths" (Godfrey 1966). All Banff and Jasper records were in the montane ecoregion.

BLACKPOLL WARBLER *Dendroica striata* **(b)** **BPWA**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: common resident
Autumn: not recorded
Winter: not recorded

The Blackpoll Warbler breeds across northern North America from Alaska and near treeline in Canada south to central parts of the provinces and, in the east, to Maine (Godfrey 1966). It nests in the northern half of Alberta and in the Rocky Mountains south to Banff (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in late May and early June. There is an unusually early record on 27 April 1977 in the middle Bow River valley (KAM); the next earliest record is 20 May 1977 in the same area. The maximum count is 12 on 5 June 1966 at Johnson Lake (Salt 1973). This unobtrusive and quiet species may be more common than surveys indicate.

In the summer it occurs throughout much of Banff and Jasper. There are no records from south of Banff townsite, and few from Front Range valleys. There are no nest records. A pair was observed carrying food, presumably to young, on 12 July 1978 near the Howse River (MED).

There are no autumn records, likely because of the retiring nature of this warbler. It is probably an uncommon migrant. The latest record is a singing male on 21 July 1978 in the middle Athabasca River valley.

HABITAT

The Blackpoll Warbler occurs almost exclusively in the lower subalpine ecoregion, but is occasionally found in the montane ecoregion. It primarily inhabits black spruce stands and coniferous bog forest, but is also found at coniferous or mixed forest edges and in burntlands. Dense young conifers appear to be a basic habitat requirement.

Highest densities of this species during the breeding season are in black spruce-lodgepole pine/willow/sedge (C8) forest (DI=15.54) and Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6) forest (DI=8.47).

PALM WARBLER *Dendroica palmarum* **PAWA**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: very rare visitor
Autumn: very rare migrant
Winter: not recorded

The Palm Warbler breeds in North America east of the Rockies from southern Mackenzie to Newfoundland, and south to central Alberta and Maine (Godfrey 1966). It breeds in north and central Alberta (Salt and Salt 1976).

There is one Jasper record, a singing male on 17 June 1978 at Sunwapta Falls (KVT). There are two Banff records, one on 12 May 1974 at Vermilion Lakes (Gordon 1975), and 1 on 13 September 1977 at Healy Creek (MED).

HABITAT

The Palm Warbler inhabits "... bogs or barrens or similar situations on either dry or wet ground where trees are scattered and where there is ground shrubbery" (Godfrey 1966). The Jasper observation was in a lower subalpine spruce/Labrador tea/brown moss (O11) bog, while both Banff records were in montane wetlands with white spruce and willows.

OVENBIRD *Seiurus aurocapillus* **OVEN**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Ovenbird breeds in North America mainly east of the Rockies, from southern Mackenzie to Newfoundland and south to Colorado and Georgia (Godfrey 1966). It nests in northern and central Alberta to the parklands, and in the foothills and, to some extent, the Rockies (Salt and Salt 1976).

There are no Banff records although they are summer residents near Seebe (GLH). There are two Jasper records from the lower Athabasca River valley, a male singing on 23 June 1979 at the East Gate, and another singing on 26 June 1980 on the Jacques Creek fan in the lower Athabasca River valley (KVT). Salt (1973) reports that he recorded an Ovenbird song near Brule on the eastern boundary of Jasper; it appears that Ovenbirds range just into the park along the lower Athabasca River.

HABITAT

The Ovenbird inhabits "deciduous closed-canopy woodlands, preferably with not too much underbrush and a good carpet of leaf litter" (Godfrey 1966). Both Jasper records were on montane alluvial fans with mixed poplar-white spruce forest and shrubby understories.

NORTHERN WATERTHRUSH *Seiurus noveboracensis* **(b)** **NOWA**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: rare migrant
Winter: not recorded

The Northern Waterthrush breeds across North America from Alaska and close to treeline in Canada south to the northern United States from Idaho eastward (Godfrey 1966). It nests in the northern half of Alberta and in the Rockies and their foothills (Salt and Salt

1976).

Spring migration in Banff and Jasper occurs in mid and late May. The earliest record is 15 May 1952 in the middle Athabasca River valley (Banfield, Jasper warden cards). The maximum count is five on 21 May 1978 at Cottonwood Slough above Jasper townsite.

In the summer it likely occurs throughout both parks. Most records are from the upper Spray River, lower Athabasca River and Miette River valleys, but one or two have been recorded in several other valleys throughout both parks. There are no nest records; however, it was "noted by Macoun as breeding around Vermilion Lakes in July, 1891 "(Clarke and Cowan 1945).

Autumn migration occurs in August. The latest record is two on 19 August 1977 near Banff townsite.

HABITAT

The Northern Waterthrush occurs in the montane and lower subalpine ecoregions. It inhabits forests, often white spruce, with tall deciduous shrubbery bordering wetlands, ponds and lakes, or floodplains that are seasonally flooded. During the breeding season the highest density of this species is in white spruce/prickly rose/horsetail (C4) forest (DI=4.61).

MACGILLIVRAY'S WARBLER *Oporornis tolmiei* **(b)** **MCWA**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

Macgillivray's Warbler breeds in western North America from southern Alaska south to California and New Mexico (Godfrey 1966). In Alberta it breeds in the Rocky Mountains and their foothills, the Red Deer River valley and the Cypress Hills.

Spring migration in Banff and Jasper occurs in mid and late May. The earliest record and highest count of four was on 19 May 1978 in the upper Athabasca River valley.

In the summer it occurs throughout most of both parks; there are no records from Jasper north of the Miette and lower Athabasca Rivers. There are no nest records. On 8 August 1943 "... a pair were feeding young just out of the nest" in the lower Athabasca River valley (Cowan 1955).

Autumn migration occurs from late August to late September, peaking in early September. The latest record on 23 September 1977 and the maximum count of six on 2 September 1977 were both near Banff townsite.

HABITAT

Macgillivray's Warbler occurs in the montane and lower subalpine ecoregions. It inhabits dense shrubbery in wetlands and near water, as well as burntlands with abundant shrub growth. The only habitat in which this species' density index is >1.00 is subalpine fir-willow (S2) avalanche slopes (DI=3.18).

NORTHERN YELLOWTHROAT *Geothlypis trichas* **(b)** **COYE**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: very common resident
Autumn: fairly common migrant
Winter: not recorded

The Northern Yellowthroat breeds across North America from the southern half of Canada to southern Mexico (Godfrey 1966). It breeds throughout Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in late April and May, peaking in late May. The earliest record is two on 24 April 1978 in the middle Bow River valley. The maximum count is 50 on 27 May 1979 in the Vermilion Lakes area (McIvor and McIvor 1980); at other locations maximum counts were less than five. It is one of the most common spring warblers.

In the summer it is distinctly commonest in the lower and middle Bow River, lower Athabasca River and Miette River valleys. However, small numbers have been recorded in several other valleys throughout both parks. The maximum count is 30 to 40 on 29 June 1979 around Vermilion Lakes (McIvor and McIvor 1980). There are no Jasper records. In Banff, there are no details of nests, although "Cowan found it nesting at the second Vermillion Lake in 1943" (Clarke and Cowan 1945). A pair was seen carrying food, presumably to young, on 2 July 1975 in the lower Bow River valley (DJK). It is one of the commonest warblers in the summer.

Autumn migration occurs in August and September, peaking in late August. The latest record is 29 September when one was seen in 1976 in the middle Athabasca River valley and seven were recorded in 1977 at Vermilion Lakes. The maximum counts of 38 and 26 were on 2 August and 2 September 1977 respectively, near Banff townsite. It is one of the commonest autumn warblers.

HABITAT

The Northern Yellowthroat inhabits willow shrubbery and sedge beds surrounding montane wetlands and lakes, and in these habitats exceptionally high densities have been recorded on call-count transects. The nighest densities are in water sedge-beaked sedge (H11) wetlands with scattered willow clumps (DI=27.44) and dwarf birch-shrubby cinquefoil/needlerush (S3) wetlands (DI=55.85).

WILSON'S WARBLER *Wilsonia pusilla* **(b)** **WIWA**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: common resident
Autumn: uncommon migrant
Winter: not recorded

Wilson's Warbler breeds across forested North America from near treeline south to California in the west and to Vermont in the east (Godfrey 1966). It breeds in extreme north and northeast Alberta, and in the Rocky Mountains (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in May and peaks in late May. The earliest record is 2 May in 1970 near Lake Louise (Gordon 1975). The maximum count, a flock of 12, occurred on 20 May 1979 in the lower Athabasca River valley. It occurs singly or in small flocks.

In the summer it occurs throughout both parks. Although it undoubtedly breeds, there are no nest records. Fledged young were being fed on 21 July 1939 in the Spray River valley (Clarke and Cowan 1945).

Autumn migration occurs from mid August to late September, peaking in late August. The latest record is one seen on 24 September 1976 in the middle Athabasca River valley. The maximum count is 16 on 2 September 1977 near Banff townsite. It is usually seen singly or in flocks of up to five, frequently with other migrant passerines.

HABITAT

Wilson's Warbler occurs from the montane to the upper subalpine ecoregion. It inhabits shrub thickets in alluvial wetlands, subalpine valley bottoms, avalanche slopes, burntlands, and subalpine fir krummholz areas at timberline.

During the breeding season the highest densities of Wilson's Warblers are in subalpine fir-willow (S2) avalanche slopes (DI=19.15) and slopes with willow-dwarf birch-shrubby cinquefoil (S10) (DI=7.56) and willow/timber oatgrass (S11) (DI=9.57) vegetation.

CANADA WARBLER *Wilsonia canadensis* **CAWA**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Canada Warbler breeds in eastern North America from Alberta to Nova Scotia, and south to Minnesota, Tennessee and New Jersey (Godfrey 1966). It breeds locally in northeast and northcentral Alberta (Salt and Salt 1976).

There is one Jasper record, a male seen on 6 June 1980 in the upper Snake Indian River valley (KAM). There are two Banff records, one on 10 May 1977 at Vermilion Lakes (KAM), and one in early June at Banff townsite (Salt and Salt 1976, no year given).

HABITAT

The Canada Warbler inhabits "... shrubby undergrowths of woodlands, tall shrubbery such as alder and willow along streams, swamps, and similar moist places" (Godfrey 1966).

AMERICAN REDSTART *Setophaga ruticilla* **(b)** **AMRE**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

The American Redstart breeds across North America in the southern half of Canada and the northern United States (Godfrey 1966). It nests in northern and central Alberta, and in all but the extreme south of the Rockies (Salt and Salt 1976).

Spring migration in Banff and Jasper lasts from mid May until early June, peaking in late May. The earliest record is a male on 9 May 1979 and the maximum count is 16 on 28 May 1978, both near Banff townsite. It is usually encountered singly or in small flocks of up to five.

In the summer it is most common in the lower and middle Bow River, lower Athabasca River and Miette River valleys. Up to six have been recorded at several other locations in Jasper. All Banff records are from the Bow valley.

Autumn migration is in August and early September. The latest record is one on 16 September 1911 in the lower Athabasca River valley. The latest recent record is one on 2 September 1977 near Banff townsite. The maximum count is 13 on 7 August 1977 near Jasper townsite. It is usually encountered singly or in flocks of up to five.

HABITAT

The American Redstart occurs primarily in the montane ecoregion, but is also regularly seen in the lower and upper subalpine ecoregion. It inhabits tall deciduous shrubbery on alluvial wetlands and avalanche slopes, as well as woodlands with a tall shrub understory, particularly near water.

During the breeding season the highest densities of redstarts are in willow-green alder/bluebell (S6) thickets (DI=40.48) and willow/horsetail (S7) thickets (DI=17.99).

HOUSE SPARROW *Passer domesticus* **(b)** **HOSP**

STATUS AND DISTRIBUTION

Spring: fairly common resident
Summer: fairly common resident
Autumn: fairly common resident
Winter: fairly common resident

The House Sparrow is native to Eurasia and northern Africa, but has been naturalized by man in many parts of the world including North America (in 1750). It now breeds in most settled parts of Canada, the United States and northern Mexico (Godfrey 1966), and nests throughout Alberta (Salt and Salt 1976).

The House Sparrow is a permanent resident of Banff and Jasper, but has a very restricted distribution. It occurs almost exclusively in the vicinity of Banff and Jasper townsites and at the Lake Louise service centre. There is only one recent record of one

recorded elsewhere, this being in the middle Bow River valley (JWW). The maximum count for Banff townsite is 80 on 6 May 1978, for Jasper townsite is 100 on 16 December 1978, and for the Lake Louise service centre area is 20 on 12 May 1975.

Although this species undoubtedly nests, there are no nest records. Sanson recorded nest building on 25 June 1913 (Clarke and Cowan 1945).

Clarke and Cowan (1945) found the House Sparrow to be a resident at Banff townsite and the Lake Louise service centre, as did Cowan (1955) at Jasper townsite. On 2 August 1930 and 1944, one was recorded in the lower Athabasca River valley, and on 24 May 1944 a pair was seen at Willow Creek (Cowan 1955). In the early 1950's, Banfield recorded flocks of up to 25 birds at several locations in the Athabasca River valley outside of Jasper townsite (Jasper warden cards).

HABITAT

The House Sparrow occurs in developed areas of the montane and lower subalpine ecoregions. It is found in townsites, at railway yards and at stables. It builds its bulky nest in a wide variety of places, including buildings, bird boxes and hollow trees.

MANAGEMENT CONSIDERATIONS

The House Sparrow is usually considered an introduced pest. It should not be encouraged to increase in distribution or numbers in the parks because it usurps the nesting places of the native bird species, which have difficulty competing because they are not as aggressive. In the winter House Sparrows are largely dependent on food from human sources including bird feeders, garbage, and grain for horses. Because they nest early, they have opportunity to pre-empt nest sites; this can be offset by plugging the entrances of nest boxes until after other bird species have returned in the spring.

BOBOLINK *Dolichonyx oryzivorus* **BOBO**

STATUS AND DISTRIBUTION

Spring: rare visitor
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Bobolink breeds across North America in parts of southern Canada and in the northern United States (Godfrey 1966). It nests irregularly in the southern half of Alberta east of the Rockies (Salt and Salt 1976).

There are no Jasper records. There are several Banff records, including a male on 24 and 25 May at Banff townsite (Gordon 1975), two pairs on 27 May 1972 in the lower Cascade River valley (GLH), three males on 28 May 1978 at Vermilion Lakes (McIvor and McIvor 1980), and two males on 4 June 1977 at Banff townsite (D. Brunton, pers. comm.).

HABITAT

The Bobolink inhabits "fields and meadows of tall grass, clover, alfalfa or grain. Also, in autumn, marshes and other open places" (Godfrey 1966). All Banff records are from montane grassland and sedge meadows.

WESTERN MEADOWLARK *Sturnella neglecta* **WEME**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: very rare visitor
Autumn: very rare migrant
Winter: not recorded

The Western Meadowlark breeds in North America from central British Columbia to southern Ontario south through the western United States to northern Mexico (Godfrey 1966). It breeds in south and central Alberta, excluding the northern Rockies (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from late March until the end of May. The earliest record is a pair on 24 March 1963 at North Saskatchewan River Crossing (JNP records). It is most frequently seen in the lower Athabasca River valley, where the maximum count is three on 28 May 1977. It has also been recorded in the lower and middle Bow River, lower Cascade River, and middle Maligne River valleys.

There are only three summer records: one on 1 June 1981 near Banff townsite (R.M. Wershler), one on 10 June 1979 at the Jasper sewage lagoon (DJH), and one on 15 June 1979 at Indianhead on the Clearwater River (KAM). Clarke and Cowan (1945) recorded it as a "summer visitant... at Banff, Scotch Camp (lower Red Deer River), and Indianhead.

In the autumn, it has only been recorded in the lower Athabasca River: one was seen on 17 October 1979 (KVT), and one on 5 November 1979 (JLK).

HABITAT

The Western Meadowlark occurs in montane grasslands, roadsides, and shrubby alluvial meadows.

YELLOW-HEADED BLACKBIRD *Xanthocephalus xanthocephalus* **YEBL**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: very rare visitor
Autumn: very rare migrant
Winter: not recorded

The Yellow-headed Blackbird breeds in western North America from central British Columbia to extreme western Ontario, and south to California and Indiana (Godfrey 1966). It nests locally in most of Alberta, except in the extreme northwest (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from late April to the end of May. The earliest record is 22 April 1977 at Banff townsite (McIvor and McIvor 1980). The maximum count is 15 on 6 May 1979 near Talbot Lake (KVT); on surveys during the three previous years, no more than 1 or 2 were seen on any one day. In Banff the maximum count is eight on 17 May 1977 at Vermilion Lakes. The only other locations where it has been recorded include at the Jasper sanitary landfill on 27 April 1979, and one at Willow Creek in May 1945 (Cowan 1955).

There are few summer records. Banff records include one on 5 June 1977 (McIvor and McIvor 1980) and three on 17-19 June 1977 (A. Gray, pers. comm.) at Banff townsite, a male on 4 June 1978 in the lower North Saskatchewan River valley (MJD) and 16 June 1971 in the middle Bow River valley (Gordon 1973). Jasper records include a female on 9-10 June 1979 at the Jasper sewage lagoon (DJH), and a male on 16 June 1977 at Sunwapta River (RGK).

There is one autumn record, one seen on 5 November 1977 at Banff townsite (McIvor and McIvor 1980).

HABITAT

Migrating Yellow-headed Blackbirds occur in montane wetlands and disturbed areas, including roadsides, landfills and sewage lagoons and stables.

RED-WINGED BLACKBIRD *Agelaius phoeniceus* **(B)** **REBL**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: common resident
Autumn: fairly common migrant
Winter: rare visitor

The Red-winged Blackbird breeds across North America in southern Canada, north to the southern Yukon and Mackenzie, and throughout most of the United States (Godfrey 1966). It breeds throughout Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper last from late March to the end of May, peaking in mid May. The earliest record is 2 March 1968 at Banff townsite (Gordon 1975). The maximum count is about 200 on 18 May 1978 at Vermilion Lakes; by far the greatest numbers occur in these extensive wetlands. The maximum count for Jasper is 46 on 25 May 1979 in the lower Athabasca River valley. The Red-winged Blackbird, along with the Brown-headed Cowbird, is one of the most common spring blackbirds.

In the summer it occurs throughout the lower valleys of both parks. In Banff, it is most common along the lower and middle Bow River. In the Vermilion Lakes area, the highest summer count was at least 100 on 29 June 1979 (McIvor and McIvor 1980). In Jasper, it is most common in the lower Athabasca River valley, where the maximum count was 23 on 7 June 1977 near the mouth of the Moosehorn Creek, and in the lower Brazeau River valley. Nests have been recorded only at the Vermilion Lakes (June 1977, GLH) but Red-winged Blackbirds do nest in several areas of the Bow and Athabasca River valleys. Along the Miette River on 30 June 1944 "several pairs were feeding nestlings" (Cowan 1955). The Red-winged Blackbird is one of the most common summer blackbirds.

Autumn migration is during early and mid August. There is an unusually late record of four on 1 October 1975 near Vermilion Lakes (DJK); the next latest record is two on 18 August 1977 at the same location. The maximum count is twenty on 2 August 1977 near Banff townsite and on 17 August 1978 in the lower Athabasca River valley. It is one of the most common autumn blackbirds.

There are several records of Red-winged Blackbirds remaining into the winter. Two were recorded on the 1978 Banff Christmas Bird Count in late December. At the Jasper sanitary landfill in 1978, two were seen on 22 November, and one 27 November and 17 December and on 5 February 1979. It is unusual for redwings to remain the entire winter.

HABITAT

The Red-winged Blackbird occurs in the montane and, to a lesser extent, lower subalpine ecoregions. It inhabits alluvial wetlands and shallow lake edges with deciduous shrubbery. On migration it also occurs at landfills and along roadsides and railway tracks.

During the breeding season high densities of this species occur in dwarf birch-shrubby cinquefoil/needlerush (S3) wetlands (DI=60.63) and water sedge-beaked sedge (H11) wetlands (DI=18.86).

NORTHERN ORIOLE *Icterus galbula* **NOOR**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Northern Oriole breeds across North America from southern Canada south to northern Mexico and South Carolina (Godfrey 1966). It breeds in south and central Alberta, east of the Rockies (Salt and Salt 1976). The Northern Oriole was formerly considered two separate species, the Baltimore and Bullock's orioles.

There are no Banff spring records. In Jasper, there are three records: a male Baltimore oriole on 22 May 1980 on the Jacques Creek fan in the lower Athabasca River valley (KAM), a flock of 8 male Baltimore orioles on 25 May 1978 in the dunes at Talbot Lake (KVT), and 1 male Bullock's oriole on 27 May 1979 along the lower Miette River (R. Richards pers. comm.).

In the summer, there is one record for each park: one on 2 June 1974 at Banff townsite (Gordon 1975), and two on 3 June 1978 in the lower Athabasca River valley (DJH).

HABITAT

The Northern Oriole inhabits open deciduous woodland, including scattered trees along rivers and streams (Godfrey 1966). Most Banff and Jasper records are from balsam poplar or mixed balsam poplar-white spruce forest in the montane ecoregion.

RUSTY BLACKBIRD *Euphazus carolinus* **(b?)** **RUBL**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: very rare resident
Autumn: rare migrant
Winter: very rare visitor

The Rusty Blackbird breeds across northern North America from near treeline south to the central western provinces, southern Ontario, and New York (Godfrey 1966). It nests in northern Alberta and less commonly in central and southwest parts (Salt and Salt 1976).

Spring migration in Banff and Jasper lasts from mid March to late May. The earliest record outside the lower Bow River area and excluding the one winter Jasper record is a flock of three on 16 March 1979 at the North Saskatchewan River Crossing. There are several records of flocks of one to five birds.

There are no recent summer records, however, there are several old records for Jasper. In the mid 1940's Cowan (1955) found a colony of 6 pairs at Snake Indian Lake and "another small colony" on Buffalo Prairie about 10 km south of Jasper townsite. On 10 June 1946, one was seen along the lower Athabasca River (Banfield, Jasper warden cards). "A pair was watched feeding young at Miette Cabin on June 28, 1946 (Cowan 1955).

In the autumn it has been recorded at Banff townsite, Vermilion Lakes and the Jasper sanitary landfill. The earliest record is ten on 12 August 1976 at the latter location (GLH). The maximum count is twelve on 24 October 1976 at Banff townsite (McIvor and McIvor 1980).

There are several winter records in the vicinity of Banff townsite. In 1976, one or two were recorded on several occasions throughout the winter, as was one in 1979 (McIvor and McIvor 1980). There is one Jasper record, one seen on 5 February 1979 at the Jasper sanitary landfill (KVT).

HABITAT

The Rusty Blackbird inhabits " wet woods and tall shrubbery where pools of water stand on the ground; bogs, partly flooded lake and stream edges, (and) beaver dams" (Godfrey 1966). On migration it is seen at disturbed areas including roadsides and landfills, in the montane and lower subalpine ecoregions. Cowan's records during the breeding season were from beaverponds in the montane and lower subalpine ecoregions.

BREWER'S BLACKBIRD *Euphagus cyanocephalus* **(B)** **BRBL**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: common resident
Autumn: fairly common migrant
Winter: rare visitor

Brewer's Blackbird breeds in western North America from central British Columbia to western Ontario, and south to Baja California, Texas and Michigan (Godfrey 1966). It nests in south and central Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper is in April and May, peaking in mid April. The earliest record is 2 April 1978 at Vermilion Lakes. A flock of about 100 was recorded on 7 April 1959 at the Buffalo Paddock at Banff townsite (Gordon 1975). It is usually seen in flocks of up to 15; the maximum count during this study was 30 on 19 April 1977 at Vermilion Lakes. It is one of the most common spring blackbirds.

In the summer it is commonest in the middle Bow River valley. Up to five were also recorded in the lower Bow River, lower Athabasca River and Clearwater River valleys. There are no nest records for Jasper. In Banff a nest with 5 eggs was found on 10 July 1975 in the middle Bow River valley at Moose Meadows (JWW). It is one of the most common summer blackbirds.

Autumn migration occurs in August and September. The latest record is one on 16 October 1978 in the lower Athabasca River valley. An unusually high count of about 200 was recorded on 9 August 1977 at the stables near Banff townsite (KAM); flocks of up to 20 are usually encountered. It is one of the most common autumn blackbirds.

There are several Banff winter records. From one to four were recorded on 1975 to 1977 Banff Christmas Bird Counts in late December. A male was seen on 5 January 1947 at Vermilion Lakes at the warm sulphur spring (BNP warden cards). It is unlikely that any Brewer's Blackbirds survive the whole winter in Banff or Jasper.

HABITAT

Brewer's Blackbird inhabits shrubby alluvial meadows in the montane and lower subalpine ecoregions; it sometimes occurs on shrubby slopes. On migration it is also found in disturbed areas, including roadsides, landfills and corrals.

Call-count transects failed to detect Brewer's Blackbirds in any but 2 vegetation types, but in these 2 types it occurs in high densities: dwarf birch-shrubby cinquefoil/needlerush (S3) wetlands (DI=54.02) and willow-dwarf birch-shrubby cinquefoil (S10) meadows (DI=10.77).

COMMON GRACKLE *Quiscalus quiscula* **COGR**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: not recorded
Autumn: very rare migrant
Winter: not recorded

The Common Grackle breeds in North America east of the Rockies from the southern half of Canada south to Colorado, Texas and Florida (Godfrey 1966). It nests throughout Alberta except in the Rockies (Salt and Salt 1976).

There is one Jasper and one Banff record of this species. At Willow Creek an adult male was collected on 24 May 1944 (Cowan 1955). In Banff townsite one was seen "... at the Harold Mortimer feeder in the autumn of 1974" (Gordon 1975).

HABITAT

The Common Grackle is found in "wet... .open places such as fields, pastures, lawns, golf courses, shores (and) marshes, or in wet alders and willows or open wet woodlands" (Godfrey 1966).

BROWN-HEADED COWBIRD *Molothrus ater* **(B)** **BRCO**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: common migrant
Autumn: common migrant
Winter: not recorded

The Brown-headed Cowbird breeds across North America from southern Canada south to northern Mexico (Godfrey 1966). It breeds throughout Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper is during late April and May, peaking in mid May. The earliest record is two on 20 April 1948 at the North Saskatchewan River Crossing (BNP warden card). Flocks of 50 to 100 are not unusual, and the maximum is about 300 recorded on 9 May 1977 near Banff townsite. Smaller numbers occur in Jasper; the maximum count was 120 on 20 May 1979 in the lower Athabasca River valley. This and the Red-winged Blackbird are the most common spring blackbirds.

In the summer this species is far more common in the lower and middle Bow River, lower Cascade River, and lower Athabasca River valleys than elsewhere in the parks. However, small numbers occur in many valleys throughout both parks, particularly in the Front Ranges. There is only one breeding record: an egg was found on 9 July 1967 at Banff townsite (Gordon 1975). The earliest records of fledged young are 26 July 1975 in the middle Bow River valley (JWW), and 26 July 1979 in the Panther River valley (JLK). It is the most common blackbird species in summer.

Autumn migration occurs from early August to mid September. The latest record is one on 8 November 1978 at the Jasper sanitary landfill. The maximum count is 175 on 3 August 1977 near Banff townsite. Far smaller numbers are encountered in Jasper; the maximum count there is 30 on 17 August 1978 along the lower Athabasca River valley. It is the most common autumn blackbird.

HABITAT

The Brown-headed Cowbird occurs in the montane and lower subalpine ecoregions. It inhabits alluvial wetlands with deciduous shrubbery or forest and, to a lesser extent, other deciduous or mixed forests. It is also seen in disturbed areas such as roadsides, horse corrals and buffalo paddocks, particularly during migration. Cowbirds are attracted to concentrations of large mammals; juveniles are also attracted to cars and people.

Highest densities during the breeding season are in dwarf birch-shrubby cinquefoil/needlerush (S3) wetlands (DI=13.16), white spruce/prickly rose/horsetail (C4) forest (DI=10.53) and aspen/hairy wild rye-peavine (C16) forest (DI=9.52).

WESTERN TANAGER *Piranga ludoviciana* **(B)** **WETA**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

The Western Tanager breeds in western North America from southern Alaska and Mackenzie and central Saskatchewan south to California and Texas (Godfrey 1966). It nests in the northern half of Alberta in the Rockies and their foothills (Salt and Salt 1976).

Spring migration in Banff and Jasper is during May. The earliest record is 30 April 1909 at Banff (Clarke and Cowan 1945). The earliest recent record is three on 6 May 1979 and the maximum count is six (4 males and 2 females) on 21 May 1979, both near Talbot Lake.

In the summer it occurs throughout the lower elevations of both parks. It is most common in the lower and middle Bow River, lower and middle Athabasca River, and Miette River valleys. It has also been recorded in the lower and upper North Saskatchewan River, Sunwapta River and lower Maligne River valleys and Cowan (1955) recorded it along the lower Snake Indian River in the 1940's. There is only one nest record for each park. On 26 June 1944 a male was seen feeding nestlings near Devona (Cowan 1955). On 19 July 1977 a nest with 2 young was found in the middle Bow River valley (MED).

Autumn migration occurs in August. The latest record is 28 August 1977 near Jasper townsite. Only one or two birds were seen on all occasions.

HABITAT

The Western Tanager occurs in the montane and, less frequently, lower subalpine ecoregions. It inhabits Douglas-fir forest and other somewhat open, mature coniferous or mixed forests. During the breeding season, highest densities of Western Tanagers are in Douglas fir/juniper/bearberry (O5) forest (DI=16.22), aspen-lodgepole pine forest (DI=4.05) and Douglas fir/hairy wild rye (C1) forest (DI=2.49).

ROSE-BREASTED GROSBEAK *Pheucticus ludovicianus* **(b)** **ROGR**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: very rare visitor
Winter: not recorded

The Rose-breasted Grosbeak breeds in central and eastern North America from northeast British Columbia across southern Canada and the northeastern United States (Godfrey 1966). It nests in north and central Alberta, east of the Rockies (Salt and Salt 1976).

There are several Banff records and two Jasper records. In Jasper, two males were seen on 25 May 1978 in the dunes near Talbot Lake (KVT), and on 10-13 August 1980 this species was recorded near Jasper townsite at Pyramid Lake (JNP warden card).

Banff records include: a male on 20 May 1977 in the middle Bow River valley (MED), one on 24 May 1977 at Vermilion Lakes (BVN 1978), a male on 31 May 1975 and 5 June 1976 at Vermilion Lakes (McIvor and McIvor 1980), a female on 6 June 1943 at Lake Minnewanka (Clarke and Cowan 1956), and a female on 23 October 1974 at Banff townsite (Gordon 1975). Also, "Sheila Douglas has had adults in the spring and complete families in late August, 1974" at her feeder in Banff townsite (Gordon 1975).

HABITAT

The Rose-breasted Grosbeak inhabits "... deciduous and mixed woodlands, ideally where larger trees grow not too far from tall shrubbery, such as along streams, lakes, ponds, and marsh edges" (Godfrey 1966). Banff and Jasper records are all from balsam poplar or aspen stands in the montane ecoregion.

BLACK-HEADED GROSBEAK *Pheucticus melanocephalus* **BHGR**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: very rare visitor
Winter: not recorded

The Black-headed Grosbeak breeds in western North America from southern British Columbia and Alberta south to southern Mexico (Godfrey 1966). In Alberta it breeds in the extreme south, including Waterton Lakes National Park; it is seen casually as far north as Kootenay Plains (Salt and Salt 1976).

There is only one Banff record of this species, a male on 10 June 1979 at Vermilion Lakes (McIvor and McIvor 1980). There is also a record from the lower Miette River on 15 August 1977 (Roy Richards, pers. comm.).

HABITAT

The Black-headed Grosbeak inhabits "more open woodlands (deciduous or mixedwood), especially where there is an admixture of tall shrubbery as along streams, ponds and lake edges, woodland openings and margins" (Godfrey 1966). Both Banff and Jasper records are from mixed balsam poplar-white spruce forest on alluvial sites in the montane ecoregion.

EVENING GROSBEAK *Hesperiphona vespertina* **(B)** **EVGR**

STATUS AND DISTRIBUTION

Spring: uncommon resident
Summer: uncommon resident
Autumn: uncommon resident
Winter: uncommon resident

The Evening Grosbeak breeds across North America from southern Canada south in the western mountains to southern Mexico, and in the east to the northern United States (Godfrey 1966). It "... probably breeds locally throughout northern and central Alberta and

in the Rocky Mountains"; "its summer distribution is poorly known" (Salt and Salt 1976).

It is a permanent resident in Banff and Jasper. On any one occasion in the summer, from one to nine were recorded in the lower Cascade River, Mistaya River, Howse River, lower North Saskatchewan River, Sunwapta River, upper Athabasca River, and middle Maligne River valleys. In 1943, a pair was seen on 8 June near Banff townsite, and another on 17 June at Healy Creek (Clarke and Cowan 1945). All winter observations but one are from Banff and Jasper townsites, with maximum counts of 74 in late December 1977 on the Banff Christmas Bird Count, and 32 on 10 March 1980 at Jasper townsite. On 13 December 1980, six were seen at Blue Creek (GLH). In spring and autumn, up to nine have been recorded at several other locations.

There are no Jasper nest records. In Banff in July 1975 an active nest (or nests) was found next to the Vermilion Pass burn in Engelmann spruce–subalpine fir forest (O'Keefe 1975; no nest details included). No other nests have been recorded in Alberta (Salt and Salt 1976).

HABITAT

The Evening Grosbeak occurs in the montane and lower subalpine ecoregions. In summer it inhabits open coniferous forests and forest edges. In winter it primarily inhabits townsites where it feeds on seeds from American ash (*Fraxinus pennsylvanicus*) Manitoba maple (*Acer negundo*), and bird feeders.

LAZULI BUNTING *Passerina versicolor* **b?** **LZBU**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Lazuli Bunting breeds in western North America from southern British Columbia, Alberta and Saskatchewan south to Baja California and Oklahoma (Godfrey 1966). In Alberta, it nests "in the Rocky Mountains and their foothills from Waterton Lakes north to Jasper and irregularly eastward to ... Lethbridge" (Salt and Salt 1976).

Although it is believed to nest in Banff and Jasper (Salt and Salt 1976), there is only one recent record of this species. On 18 June 1977, a male was singing at the Sawback picnic area in the middle Bow River valley (A. Grey, pers. comm.)

In 1891, Macoun considered it "not common" at Banff (Clarke and Cowan 1945). In June and July 1918, four specimens were collected in Jasper park (Cowan 1955).

HABITAT

The Lazuli Bunting inhabits "brushy country, burntlands, and clearings" (Godfrey 1966). It has been recorded in aspen/hairy wild rye–peavine (C16) forest in Banff, in the montane ecoregion.

PURPLE FINCH *Carpodacus purpureus* **(b)** **PUFI**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: uncommon resident
Autumn: rare migrant
Winter: very rare visitor

The Purple Finch breeds across North America in forested parts of southern Canada and the northern United States south to Baja California and West Virginia (Godfrey 1966). It breeds locally in north and central Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper is in late April and May. There is an unusually early record of one singing on 22 March 1979 in the Alexandra River valley (MAS). The next earliest record of 10 on 29 April 1978 and the maximum count of 15 on 10 May 1978 were both near Banff townsite. It is usually in flocks of one to five.

In the summer it likely occurs throughout both parks. From one to five were recorded in several valleys of both parks. There are no nest records. However, "Macoun states that purple finches were breeding at Banff in 1891" (Clarke and Cowan 1945), and fledged young were seen at Jasper townsite on 28 June 1944 (Cowan 1955).

Autumn migration occurs in August. The latest record and maximum count is three on 27 August 1976 at the Valley of Five Lakes in the middle Athabasca River watershed.

HABITAT

The Purple Finch occurs in the montane and lower subalpine ecoregions. It inhabits primarily pine and spruce forests, usually with some aspen or balsam poplar intermixed.

CASSIN'S FINCH *Carpodacus cassinii* **CAFI**

STATUS AND DISTRIBUTION

Spring: rare visitor
Summer: rare visitor
Autumn: very rare visitor
Winter: not recorded

Cassin's Finch breeds in western North America from southern British Columbia and southwest Alberta south to California and New Mexico (Godfrey 1966). The extent of its breeding range in Alberta beyond Waterton Lakes National Park is not known (Salt and Salt 1976).

There are two Jasper records. A pair was seen near Pyramid Lake for three days in May 1975, and on 20 October 1976 at least four were again seen in the same area (Salt 1977).

There are several recent Banff records. At Banff townsite up to eight were seen from 31 May to 19 June 1977 (Brunton et al. 1978), five on 4 June 1977 (E. Tull, pers. comm.), one on 17 to 19 June 1977 (A. Gray, pers. comm.) and one on 28 May 1978 (McIvor and McIvor 1980). A female was seen on 8 June 1978 in the lower Bow River valley (GLH).

HABITAT

Cassin's Finch inhabits "open coniferous forests in the western mountains ranging up to considerable altitudes" (Godfrey 1966). The Jasper records are from open montane Douglas fir/hairy wild rye (C1) forest, while the Banff records are from pine/aspen stands in the montane ecoregion.

HOUSE FINCH *Carpodacus mexicanus* **HOFI**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: not recorded
Autumn: not recorded
Winter: not recorded

The House Finch breeds in western North America, mainly west of the Rockies, from southern British Columbia to southern Mexico (Godfrey 1966). There are only a few Alberta records (Salt and Salt 1976).

There is one Jasper record: an adult male was collected on 30 May 1944 at Blue Creek near Topaz Lake (Cowan 1955). House finches occur near Radium Hot Springs B.C. (Van Tighem 1977) but have not been recorded in Banff. At least one pair of House Finches spent the summer of 1981 in Canmore, east of Banff (GLH).

HABITAT

The House Finch prefers "sunny drier areas... with at least some water available... (and) towns" (Godfrey 1966).

PINE GROSBEAK *Pinicola enucleator* **(b)** **PIGR**

STATUS AND DISTRIBUTION

Spring: fairly common resident
Summer: common resident
Autumn: fairly common resident
Winter: fairly common resident

The Pine Grosbeak is a holarctic species breeding, in North America, across forested regions of the continent from treeline south to California in the Rockies and central Ontario and Maine in the east (Godfrey 1966). In Alberta, it breeds in the Rockies and possibly in northern parts (Salt and Salt 1976).

It is a permanent resident throughout Banff and Jasper, although some may leave the parks in the winter. In the spring and summer it is usually encountered singly or in pairs, with up to five having been recorded at once. At other times, it is most often encountered singly or in flocks of up to 20. Excluding townsites, the maximum count of 40 was on 5 February 1980 in the upper Rocky River valley. The number recorded in late December on Banff Christmas Bird Counts fluctuates greatly from year to year, varying from 5 to a maximum of 160 in 1977.

There are no nest records. Two young were seen with adults on 19 August 1978 along the Pipestone River (MJD), and two young were seen on 28 August 1979 in the middle Cascade River valley (JLK).

HABITAT

In the summer, the Pine Grosbeak inhabits coniferous forests of the upper and lower subalpine ecoregions. The highest densities are in Engelmann spruce-subalpine fir/false azalea (C14) forest (DI=4.14), Engelmann spruce-subalpine fir/grouseberry (C15) forest (DI=4.46), and lodgepole pine/buffaloberry/grouseberry (C18) forest (DI=4.37).

In the winter, some birds move into coniferous forests of the montane ecoregion and into townsites where they feed on seeds of ornamental trees such as Ash (*Fraxinus pennsylvanicus*) or at bird feeders.

GRAY-CROWNED ROSY FINCH *Leucosticte tephrocotis* **(B)** **GRFI**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: very common resident
Autumn: common migrant
Winter: very rare visitor

The Gray-crowned Rosy Finch breeds in the mountains of western North America from Alaska to California, including the Rocky Mountains of western Alberta (Godfrey 1966). It winters in southeastern Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from mid March to early May, peaking in late April. The earliest record is a flock of 120 on 17 March 1979 at the railroad tracks at Vermilion Lakes (McIvor and McIvor 1980). The maximum spring count is more than 1000 on 17 April 1977 along the railway tracks at Vermilion Lakes (Bow Valley Naturalists 1978). In Jasper fewer Gray-crowned Rosy Finches are recorded in spring, the maximum count being 31 on 21 April 1976 in the middle Maligne River valley. This is one of the commonest spring finches, with flocks of 10 to 100 not being uncommon.

In the summer it is ubiquitous in the alpine. There are few nest records due to the inaccessability of this species' nest sites. One nest was found on 18 July 1977 at Wilcox Pass (JRS). Clarke and Cowan (1945) reported 12 pairs carrying food to nestlings on Molar Pass on 20 July 1943 and there are several more recent records of adults carrying food to young. The earliest record of fledged young is 17 July 1944 in the Restless River drainage (Cowan 1955). Flocks of Gray-crowned Rosy Finches are seen during the summer, with the largest flock on record being 90 on 4 July 1979 in Cairn Pass. This is second only to the Pine Siskin in abundance among the finches that summer in Banff and Jasper.

Autumn migration lasts from August until early November, peaking in late September and October. The latest November record is a flock of 30 recorded on 3 November 1947 at North Saskatchewan River Crossing (BNP warden card). Flocks vary from a few to a maximum of 200 on 21 September 1979 in the lower Red Deer River drainage and on 16 October 1978 at Vermilion Lakes (McIvor and McIvor 1980). This is the second most common finch in Banff and Jasper in autumn.

There are several winter records. One was recorded on each of the 1962 and 1975 Banff Christmas bird counts. At Banff townsite 17 were observed on 6 January 1977 (McIvor and McIvor 1980) and a male on 23 January 1968 (Gordon 1975). Clarke

and Cowan (1945) cite records in February 1910 and March 1914. In Jasper, three were seen on 17 February 1979 in the lower Athabasca River valley (JLK).

HABITAT

On migration the Gray-crowned Rosy Finch occurs at all elevations in open areas such as river channels, railroad clearings and roadsides, but during the breeding season it is confined to the upper subalpine and alpine ecoregions. It is most common in tundra and heath meadows at and above timberline and, less commonly, on grassy avalanche slopes and talus or other colluvial debris. It nests in crevices in cliffs or under rocks. Highest summer densities are in mountain avens-snow willow-moss campion (H1) tundra (DI=24.11) and heather-everlasting (L5) meadows (DI=21.24).

HOARY REDPOLL *Acanthis hornemanni* **HORE**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: not recorded
Autumn: not recorded
Winter: uncommon resident

The Hoary Redpoll breeds throughout the arctic region including Alaska, the Canadian Arctic and Greenland (Godfrey 1966). In Alberta it is a winter visitor, less common than the Common Redpoll (Salt and Salt 1976).

In Banff and Jasper this species is a winter resident, arriving in December and departing by mid April. The earliest record and maximum count is 12 on 7 December 1977 in the lower Cascade River valley (MED). Up to 6 have been been recorded on Banff Christmas bird counts, compared to a maximum count of 127 Common Redpolls. The latest record is 11 April 1968 at Banff townsite (Gordon 1975). There are no February records and only a single January record from the Vermilion Lakes. Because the two redpoll species are similar in appearance, Hoary Redpolls may be somewhat more common than the paucity of records would indicate. On 2 and 3 April 1941 flocks of redpolls observed at Blue Creek were judged to be one third Hoary Redpolls (Cowan 1955).

HABITAT

The Hoary Redpoll is commonest along roadsides and in grassy or shrubby meadows in the montane and lower subalpine ecoregions. It particularly favors alders and birch whose seeds it eats.

COMMON REDPOLL *Acanthis flammia* **CORE**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: very rare visitor
Autumn: common migrant
Winter: common resident

The Common Redpoll breeds throughout the arctic region, including Alaska, the Canadian Arctic and Greenland (Godfrey 1966). It is a winter visitor to all parts of Alberta and, in 1974, was found nesting near Edmonton (Salt and Salt 1976).

In Banff and Jasper this species is a winter resident, arriving in late October and departing by late April. The earliest record is 12 October 1896 in the middle Athabasca River valley (Cowan 1955). The earliest recent record is 26 October 1977 near Jasper townsite. The maximum count is 200 on 27 October 1974 in the upper Bow River valley (BNP warden card).

During the winter Common Redpolls occur in small numbers in the lower valleys of both parks. Flocks of more than 30 have been recorded in the lower Bow River, middle Cascade River, lower Athabasca River and Miette River valleys and at Jasper townsite. Banff Christmas bird count records vary from one to a maximum of 127 Common Redpolls in 1962.

Spring migration is during March and April, with the latest recent record being 26 April 1979 in the lower Athabasca River valley. Clarke and Cowan (1945) reported that in Banff "... it lingers in spring as late as May 12". The maximum count is 120 on 10 April 1978 at Howse Pass (MJD).

HABITAT

The Common Redpoll occurs most commonly in alluvial areas, roadsides and disturbed areas in the montane and lower subalpine ecoregions. It prefers meadows, alder thickets, tall shrubbery and forest edges. On migration it has been observed in the upper subalpine ecoregion.

PINE SISKIN *Spinus pinus* **(B)** **PISI**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: abundant resident
Autumn: common migrant
Winter: rare resident

The Pine Siskin breeds in wooded areas across North America from Alaska and the southern half of Canada south to Guatamala, excluding the southeast United States (Godfrey 1966). It breeds throughout Alberta except in the southeast prairies (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs from mid March to late May, peaking in mid to late May. The earliest record is 4 March 1947 at Banff townsite (BNP warden card). The highest count is 109 on 31 May 1976 in the middle Athabasca River valley.

Flocks in the spring usually number up to ten. The largest flock, with 40 birds, was seen on 31 May 1978 in the lower North Saskatchewan River valley. This is the most common of the grosbeaks and finches.

In the summer the Pine Siskin is ubiquitous. It occurs singly or in flocks of varying size, the largest recorded being 50 on 5 July 1977 in the middle Bow River valley and 15 June 1977 in the upper Athabasca River valley. There is only one nest record, a nest with 3 young found on 14 July 1978 near the Howse River (MED). Adults were observed feeding a fledged young on 4 August 1975 in the middle Bow River valley (JWW). This is the most common species of bird in Banff and Jasper in summer.

Autumn migration occurs from mid August to early November, peaking from late August to mid September. Although they usually occur singly or in flocks of up to 20 birds, flock size can be considerably greater than in the spring. The largest flock, with 150, was seen on 27 August 1976 in the upper North Saskatchewan River valley. This is the most common finch in autumn.

The occasional late migrant is seen in the early winter. The latest record is two seen on 14 December 1978 in the Siffleur River valley (MAS).

HABITAT

The Pine Siskin occurs from the montane to the upper subalpine ecoregions, and is occasionally seen in the alpine. It inhabits all types of forests, but is most common in coniferous woods. Highest summer densities (based on call-count transects) are in lodgepole pine/false azalea/grouseberry (C20) forest (DI=90.06), Engelmann spruce-subalpine fir/valerian-fleabane (09) forest (DI=84.30), Engelmann spruce-subalpine fir/false azalea (C14) forest (DI=57.95), open subalpine larch/heath forest forest (DI=56.85), lodgepole pine/feathermoss (C11) forest (DI=48.49) and aspen/hairy wild rye-peavine (C16) forest (DI=46.42). It forages in a variety of habitats including open meadows and disturbed areas where it feeds on the seeds of dandelion and other plants.

AMERICAN GOLDFINCH *Spinus tristis* **AMGO**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: very rare visitor
Autumn: very rare visitor
Winter: not recorded

The American Goldfinch breeds across North America from southern Canada south to Baja California and South Carolina (Godfrey 1966). It nests in central and southern Alberta and has been recorded in the Rocky Mountains north to Canmore and Seebe (Salt and Salt 1976).

There are no Jasper records but there are several from Banff as far north as Wigmore Lake. Other than one on 30 May 1976 at Vermilion Lakes (GLH) and one heard calling on 4 June 1979 in the lower Bow River valley (GRB), all records of this species are from the early autumn.

An adult male was seen on 31 July and 4 August 1972 at Banff townsite (Gordon 1975), one was seen on 20 August 1978, three on 23 August 1979 at Vermilion Lakes (McIvor and McIvor 1980), and two were seen on 28 August 1979 near Wigmore Lake (JLK).

HABITAT

The American Goldfinch inhabits "... weedy places not too far from wood edges or patches, second growths, tall shrubs... (and) open deciduous woods or shrubs" (Godfrey 1966). Disturbed areas where thistles, dandelions and other composites are common are particularly favoured by goldfinches since they use these plants for food and nesting material. All but one of the Banff records of American Goldfinches are from open habitats in the montane ecoregion.

RED CROSSBILL *Loxia curvirostra* **(b?)** **RECR**

STATUS AND DISTRIBUTION

Spring: fairly common resident
Summer: fairly common resident
Autumn: fairly common resident
Winter: fairly common resident

The Red Crossbill breeds in boreal coniferous forests across Eurasia and North America. It breeds from Alaska and Newfoundland south to Baja California in the Rockies, and to Wisconsin and North Carolina in the east (Godfrey 1966). It nests in north and southwest Alberta to the edge of the parklands (Salt and Salt 1976).

It is a permanent resident in Banff and Jasper and has been recorded in most valleys. Both this species and the White-winged Crossbill are known to move erratically from one region to another, with resulting fluctuations in numbers from year to year within an area. Although its occurrence was erratic, there were no obvious fluctuations during this study; possibly fluctuations are less pronounced in the mountains. Most often only ten or fewer of this gregarious species were recorded at any one time, although flocks of up to 20 were not unusual. The largest flock, with 30, was seen on 31 July 1978 in the Mistaya River valley. The maximum count is 51 birds in late December 1976 around Banff townsite on the Banff Christmas Bird Count; in some years none are recorded. The maximum Jasper count is 30 on 11 December 1979 at Jasper townsite.

There are no nest records. A lone immature was seen on 5 July 1977 in the middle Bow River valley (MED). Pairs nest at any time from spring to autumn.

HABITAT

The Red Crossbill occurs in the montane and lower subalpine ecoregions and, to a lesser extent, the upper subalpine ecoregion. It inhabits coniferous and mixed coniferous/deciduous forests. It is most commonly seen where there are mature coniferous trees, whose seeds it eats.

WHITE-WINGED CROSSBILL *Loxia leucoptera* **(b)** **WHCR**

STATUS AND DISTRIBUTION

Spring: fairly common resident
Summer: fairly common resident
Autumn: fairly common resident
Winter: fairly common resident

The White-winged Crossbill breeds in boreal coniferous forests in Eurasia, and North America, in North America breeding from Alaska and Newfoundland south to the northern United States (Godfrey 1966). It nests in north and southwest Alberta to the edge of the parklands (Salt and Salt 1976).

It is a permanent resident in Banff and Jasper, and has been recorded in most valleys. Like the Red Crossbill it is known for its erratic movements from one region to another, causing fluctuations in numbers from year to year within an area. There was little evidence of fluctuations during the period 1975 to 1981. Most often flocks of fewer than ten were encountered, although larger flocks are not unusual. The largest flock recorded was thirty seen on 17 June 1977 in the lower Bow River valley. The maximum count is 148 on 20 December 1980 around Banff townsite on the Banff Christmas Bird Count; in some years none were recorded.

There are no nest records. Pairs nest at any time of the year. There are more than 15 records of singing males (inventory files).

HABITAT

The White-winged Crossbill occurs in the montane and lower subalpine ecoregions, and, to a lesser extent, the upper subalpine ecoregion. It inhabits all types of coniferous forests, preferring closed forests with mature trees whose seeds it eats.

RUFOUS-SIDED TOWHEE *Pipilo erythrophthalmus* **RUTO**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: very rare visitor
Autumn: not recorded
Winter: not recorded

The Rufous-sided Towhee breeds across North America from extreme southern Canada south to Guatemala (Godfrey 1966). It nests in southeast Alberta along prairie rivers and coulees west to Calgary (Salt and Salt 1976).

There are no Jasper records. There are two records from Banff townsite: one was seen in Banff from 7 to 9 June 1908 (Samson, from Clarke and Cowan 1945), and one on 31 March and 1 April 1979 at a feeder (Banff warden card).

HABITAT

The Rufous-sided Towhee inhabits "bushy areas and thickets with an accumulation of leaf litter on the ground: brushy fields, willow-alder patches, woodland edges and openings" (Godfrey 1966). Both Banff records were in the montane ecoregion.

LARK BUNTING *Calamospiza melanocorys* **LKBU**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: not recorded
Autumn: not recorded
Winter: not recorded

The Lark Bunting breeds in central North America from the southern prairie provinces south to New Mexico and Kansas (Godfrey 1966). In Alberta it nests locally on the prairies in the extreme southeast, west to Calgary (Salt and Salt 1976).

There are no Jasper records. A specimen was collected in May 1881 by Spreadborough at Banff townsite (Clarke and Cowan 1945).

HABITAT

The Lark Bunting inhabits "drier treeless plains and prairies, especially where the grasses have a considerable admixture of sagebrush" (Godfrey 1966).

SAVANNAH SPARROW *Passerculus sandwichensis* **(B)** **SASP**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: very common resident
Autumn: uncommon migrant
Winter: not recorded

The Savannah Sparrow is found throughout North America from the arctic coast south to Guatemala, excluding the southeastern United States (Godfrey 1966). It breeds throughout Alberta, and is the most widely-distributed sparrow in the province (Salt and Salt 1976).

Spring migration in Banff and Jasper is during late April and May, peaking in early to mid May. The earliest record is two on 22 April 1980 in the lower Bow River valley. The maximum count is 40 near Banff townsite on 3 May 1978, but fewer than 10 are usually recorded on any survey.

The Savannah Sparrow breeds in summer throughout Banff and Jasper. Although there are no Banff nest records adults were seen carrying food at two different locations in the middle Bow River watershed on 20 and 23 July 1975 (JWW). There are numerous Jasper nest records, the earliest being a nest with 5 eggs on 16 June 1978 near Maligne Lake (MAS). A nest with 2 young and 2 eggs was found on 21 June 1977 in the Sunwapta River valley (DJK). The earliest record of a fledged young is 24 July 1978 in the upper Bow River valley (MED). This species is one of the commonest breeding sparrow species in Banff and Jasper.

Autumn migration is from mid August to early October. Only small numbers are recorded on any one survey, the maximum count being four on several occasions. The latest record is an individual on 11 October 1977 near Jasper townsite.

HABITAT

The Savannah Sparrow occurs from the montane to the upper subalpine, being most common in the lower subalpine ecoregion. It occurs in a variety of open habitats but is most abundant in moist meadows with sedge or dwarf birch and willow vegetation. Highest densities during the breeding season are in dwarf birch-willow/kobresia (S9) meadows (DI=43.86), water sedge-beaked sedge (H11) meadows (DI=43.40), willow/ cinquefoil (S8) meadows (DI=21.93) and willow/timber oatgrass (S11) meadows (DI-21.41).

GRASSHOPPER SPARROW *Ammodramus savannarum* **GRSP**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: not recorded
Autumn: not recorded
Winter: not recorded

The Grasshopper Sparrow breeds across North America from parts of extreme southern Canada to the southern United States, and from southern Mexico through Central America to Colombia and Ecuador (Godfrey 1966). It was first sighted in Alberta in 1945, and is now known to nest in the extreme southeast, and has been sighted as far west as Calgary (Salt and Salt 1976).

There are no Jasper records. In Banff a male was seen on 18 May 1977 along the railway at Banff townsite (KAM).

HABITAT

The Grasshopper Sparrow inhabits "old fields, hayfields, and prairies with clumps of grass and weeds. Situations are usually drier than those chosen by (the) Savannah Sparrow" (Godfrey 1966). In Banff the only record is from disturbed grassland in the montane ecoregion.

BAIRD'S SPARROW *Ammodramus bairdii* **BASP**

STATUS AND DISTRIBUTION

Spring: very rare visitor
Summer: not recorded
Autumn: not recorded
Winter: not recorded

Baird's Sparrow breeds in west central North America from southern Alberta and Manitoba south to Montana, South Dakota and Minnesota (Godfrey 1966). It nests very locally in southeastern Alberta, west to Calgary (Salt and Salt 1976).

There are no Jasper records. In Banff one was seen on 31 May 1977 at Banff townsite (Brunton et al. 1978).

HABITAT

Baird's Sparrow inhabits " dry grassy areas where the grass is fairly long and often where scattered low shrubs are present for singing perches." (Godfrey 1966).

LECONTE'S SPARROW *Ammospiza leconteii* **(b?)** **LESP**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: uncommon resident
Autumn: not recorded
Winter: not recorded

Leconte's Sparrow breeds from the Northwest Territories and central Ontario south to Michigan and Montana (Godfrey 1966). It nests in north and central Alberta east of the Rockies, and locally further south (Salt and Salt 1976).

Although there are no Banff records, Leconte's Sparrow appears to breed locally in Jasper. Populations have been recorded along the lower Brazeau River near Isaac Creek (6 singing males and 5 others on 2 June 1979, 2 singing males on 28 June 1979) and at Pocahontas Ponds along the lower Athabasca River (3 singing males on 11 June 1980). It is also reported to breed at Pyramid Lake near Jasper townsite but no details are available (Salt and Salt 1976). Leconte's Sparrows have been recorded in the lower Athabasca River valley historically. Several were seen in 1946 and one was collected at Pocahontas on 3 June and another on an island 6 miles north of Jasper townsite on 5 June (Cowan 1955). Banfield saw one at Pocahontas on 13 June 1946 (Jasper warden card).

HABITAT

Leconte's Sparrow occurs in the montane and lower subalpine ecoregions in wet, seasonally or permanently flooded grass and sedge meadows or wet grass and willow tangles.

SHARP-TAILED SPARROW *Ammospiza caudacuta* **SHSP**

Spring: not recorded
Summer: not recorded
Autumn: very rare migrant
Winter: not recorded

The sharp-tailed sparrow breeds locally in central and eastern North America from southern Mackenzie, central Manitoba, James Bay and New Brunswick south to South Dakota, Minnesota and North Carolina (Godfrey 1966). It nests locally across the northern half of Alberta, south to Red Deer (Salt and Salt 1976).

There are no Jasper records. In Banff one was reported on 2 August 1945 in the lower North Saskatchewan River valley near the Graveyard Flats (J. Hatter field notes).

HABITAT

This species frequents marshy areas with tall vegetation.

VESPER SPARROW *Pooecetes gramineus* **(b)** **VESP**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: uncommon resident
Autumn: uncommon migrant
Winter: not recorded

The Vesper Sparrow breeds across temperate North America from interior British Columbia and Nova Scotia south to California and North Carolina (Godfrey 1966). It nests throughout Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in May, peaking in late May. The earliest record is 26 April 1975 at Vermilion Lakes (McIvor and McIvor 1980). The maximum count is four on 31 May 1976 in the middle Athabasca River valley.

In the summer, it is most common in the lower Athabasca River valley. All but four of 27 recent Jasper records are from here, the exceptions being two seen on 4 June 1980 (probably migrants) at Blue Creek, a migrant on 5 May 1979, a singing male on 4 July 1976 in the middle Athabasca River valley, and three on 26 August 1980 in the lower Brazeau River valley. In Banff singing males were recorded in the lower and middle Bow River, Fortymile Creek and lower Red Deer River valleys.

There are no nest records, although the species almost certainly breeds here.

Autumn migration is in August. The latest record is 17 September 1977 in the lower Athabasca River valley. The maximum count is a flock of 25 on 14 August 1979 in the lower Bow River valley (HFC). Flocks of more than five are rarely observed.

HABITAT

The Vesper Sparrow occurs primarily in the montane ecoregion, but is occasionally found in the lower subalpine ecoregion. It inhabits dry, sparse grassland, usually where there are scattered pines and/or spruce (DI=9.45). On migration, it is also seen along roadsides and railway tracks. There is an unusual record of at least two singing males on a grassy avalanche slope in the lower subalpine from 28 to 30 June 1979 in the Fortymile Creek watershed (GRB).

DARK-EYED JUNCO *Junco hyemalis* **(B)** **DAJU**

STATUS AND DISTRIBUTION

Spring: very common migrant
Summer: abundant resident
Autumn: common migrant
Winter: rare visitor

The Dark-eyed Junco breeds from arctic treeline south throughout the forested parts of North America to Baja California and to Minnesota, Georgia and New York (Godfrey 1966). It nests in all of Alberta except the southeastern prairies (Salt and Salt 1976).

The Dark-eyed Junco is represented in Banff and Jasper by two subspecies which interbreed freely; the Slate-colored Junco was considered a distinct boreal species and

the Oregon Junco a distinct cordilleran species until the two were lumped by taxonomists in 1973.

Spring migration in Banff and Jasper is from mid March to mid May, peaking in April. The earliest record is 9 March 1980 at Jasper townsite. The maximum count is 267 on 2 April 1978 in the Banff townsite area. Most flocks are of fewer than ten. This is the most abundant spring migrant next to the robin.

In summer the Dark-eyed Junco is one of the most common and widespread breeding species in Banff and Jasper. Only the Pine Siskin and Chipping Sparrow are more common. There are numerous nest records. The earliest is a nest with 4 eggs on 19 May 1944 at Willow Creek (Cowan 1955). Nestlings were first recorded on 7 June 1975 in the middle Bow River valley (DJK) and the earliest fledged young was seen on 23 June 1977 in the upper Athabasca River valley (JDS).

Autumn migration lasts from mid August to late October, peaking in September. The maximum count is 100 on 26 September 1953 along the Icefields Parkway in Jasper (JNP warden card). Flocks of fewer than 25 are usual, however a flock of 90 was recorded on 17 August 1975 in the middle Bow River valley (DJK). The Dark-eyed Junco is the most common autumn migrant in Banff and Jasper, after the Bohemian Waxwing.

An occasional straggler will remain into early winter and the odd individual may overwinter at Banff townsite. The latest Jasper record is 5 November 1978 at Jasper townsite.

In Banff Dark-eyed Juncos are regularly recorded in mid December on Banff Christmas Bird Counts. Later records include one on 12 January 1967 and on 1 and 23 January 1972 at Banff townsite (Gordon 1975). In the early 1900's juncos were thought to sometimes remain the entire winter at Banff townsite; one was said to have done so in 1911-12 (Clarke and Cowan 1945).

In the 1940's, the Slate-colored Junco was considered an "abundant" summer resident", and the Oregon Junco a migrant or visitor (Clarke and Cowan 1945, Cowan 1955). At present, the Oregon Junco subspecies breeds throughout Banff and Jasper, and the Slate-colored Junco subspecies breeds mainly in the valleys of the lower Bow River, lower Red Deer River, lower North Saskatchewan River and lower Athabasca River.

HABITAT

The Dark-eyed Junco occurs from the montane to the upper subalpine ecoregion. It inhabits all types of forests and forest edges but occurs at its highest densities (DI>20.00) in the following vegetation types:

Douglas fir/hairy wild rye (C1) forest
lodgepole pine/juniper/bearberry (C3) forest
white spruce/prickly rose/horsetail (C4) forest
lodgepole pine/buffaloberry/showy aster (C6) forest
aspen/hairy wild rye-peavine (C16) forest
lodgepole pine/false azalea/grouseberry (C20) forest
white spruce/buffaloberry/fern moss (C26) forest
aspen-lodgepole pine forest
white spruce/shrubby cinquefoil/bearberry (O3) open forest
Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14) open forest
subalpine fir-willow (S2) avalanche slopes

On migration juncos are commonly seen in shrubby areas and along roadsides and railway tracks.

TREE SPARROW *Spizella arborea* **TRSP**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: not recorded
Autumn: very rare migrant
Winter: not recorded

The Tree Sparrow breeds across northern North America from the arctic coast south to the northern parts of the provinces, excluding Alberta (Godfrey 1966). It migrates through Alberta in spring and autumn and occasionally winters in small numbers in the southern part of the province (Salt and Salt 1976).

Tree Sparrows have been reported near Wilcox Pass in Jasper in October (J.R. Salt, pers. comm.) and on the Whistlers road on 11 October 1975 (E. Tull, pers. comm.). In Banff it has been recorded both in spring and autumn, mostly in the lower Bow River valley.

An unspecified number was seen on 11 April 1970 in the Alexandra River valley (Gordon 1975). At Banff townsite two were seen on 10 April and one on each of 19 April and 8 May 1976 (McIvor and McIvor 1980).

Clarke and Cowan (1945) reported two possible records of males singing in June "... on two of the higher summits... " in Banff. There are no recent summer records.

There are two autumn records for Banff. Two Tree Sparrows were seen on 8 October 1979 at Banff townsite and an unspecified number was recorded on 30 November 1974 in the Mistaya River valley (Gordon 1975).

HABITAT

The Tree Sparrow inhabits "... open woody shrubbery such as willow, dwarf birch, and alder, sometimes scrub conifers along streams, in bogs, and above timberline in the western mountains" (Godfrey 1966). In winter and on migration it is seen in "... weedy fields, gardens, and similar open places that provide weed seeds" (ibid). The Banff records include sightings at the horse stables and along railway tracks and roadsides, while in Jasper the species was reported in upper subalpine willow scrub near timberline and along a roadside in the montane ecoregion.

CHIPPING SPARROW *Spizella passerina* **(B)** **CHSP**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: abundant resident
Autumn: common migrant
Winter: not recorded

The Chipping Sparrow breeds across North America from near treeline south to Nicaragua (Godfrey 1966). It nests throughout Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in May and early June, peaking in late May and early June. The earliest record is four on 30 April 1977 in the middle Maligne

River valley. Chipping Sparrows are usually encountered singly or in flocks of up to 20; an unusually large flock of about 200 was seen on 16 May 1977 in the middle Bow River valley (MED). This is one of the more common spring sparrows.

In the summer it is found throughout both parks. There are two Jasper nest records, and numerous records for Banff. The earliest is a nest with 4 eggs on 11 June 1946 in the lower Athabasca River valley (Cowan 1955). The earliest record of hatched young is a nest with 3 young on 21 June 1979 in the lower Bow River valley (KAM). The earliest fledged young was seen on 6 July 1977 at Healy Creek (GLH). The Chipping Sparrow is the most common breeding bird in Banff and Jasper next to the Pine Siskin.

Autumn migration occurs in late July and August, peaking in early August. The latest record is 13 September 1977 in the upper Athabasca River valley. The maximum count is 59 on 7 August 1977 near Jasper townsite. It usually occurs in flocks of up to 30 birds; an unusually large flock of about 100 was seen on 15 July 1977 in the lower Bow River valley (MED). That it can be exceptionally abundant in autumn is shown by the fact that "... in August, 1943, along the Snake Indian Valley the migrant flocks of this sparrow numbered thousands of birds" (Cowan 1955).

HABITAT

The Chipping Sparrow occurs from the montane to the upper subalpine ecoregion but is most abundant in dry montane coniferous forest, especially in more open stands. It occurs at its highest densities (DI> 20.00) in the following vegetation types:

white spruce/shrubby cinquefoil/bearberry (O3) open forest
lodgepole pine savannah
Engelmann spruce–subalpine fir/willow/ribbed bog moss (O6) open forest
open subalpine larch/heath forest open forest
white spruce/juniper/bearberry (O17) open forest
aspen/hairy wild rye–peavine (C16) forest
lodgepole pine/dwarf bilberry (C9) forest
aspen–lodgepole pine forest
Douglas fir/hairy wild rye (C1) forest

It also frequents forest edges, tall shrubbery and townsites, and on migration it is found in a variety of disturbed habitats including roadsides and railways.

CLAY-COLOURED SPARROW *Spizella pallida* **(b)** **CLSP**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: fairly common resident
Autumn: uncommon migrant
Winter: not recorded

The Clay-coloured Sparrow breeds in interior North America from southern Mackenzie and southern Ontario to Texas and Michigan (Godfrey 1966). It nests throughout Alberta, but is most common on the prairies and parkland (Salt and Salt 1976).

Spring migration in Banff and Jasper is during mid May and early June. The earliest record is 17 May 1977 at Vermilion Lakes. The maximum count is five on 21 May 1979 at Jasper townsite.

In the summer it occurs in many valleys throughout both parks. It is most common in the lower and middle Bow River and lower Athabasca River valleys (Figure

Figure 3.24. Distribution of Clay-coloured and Brewer's Sparrow observations in Banff.

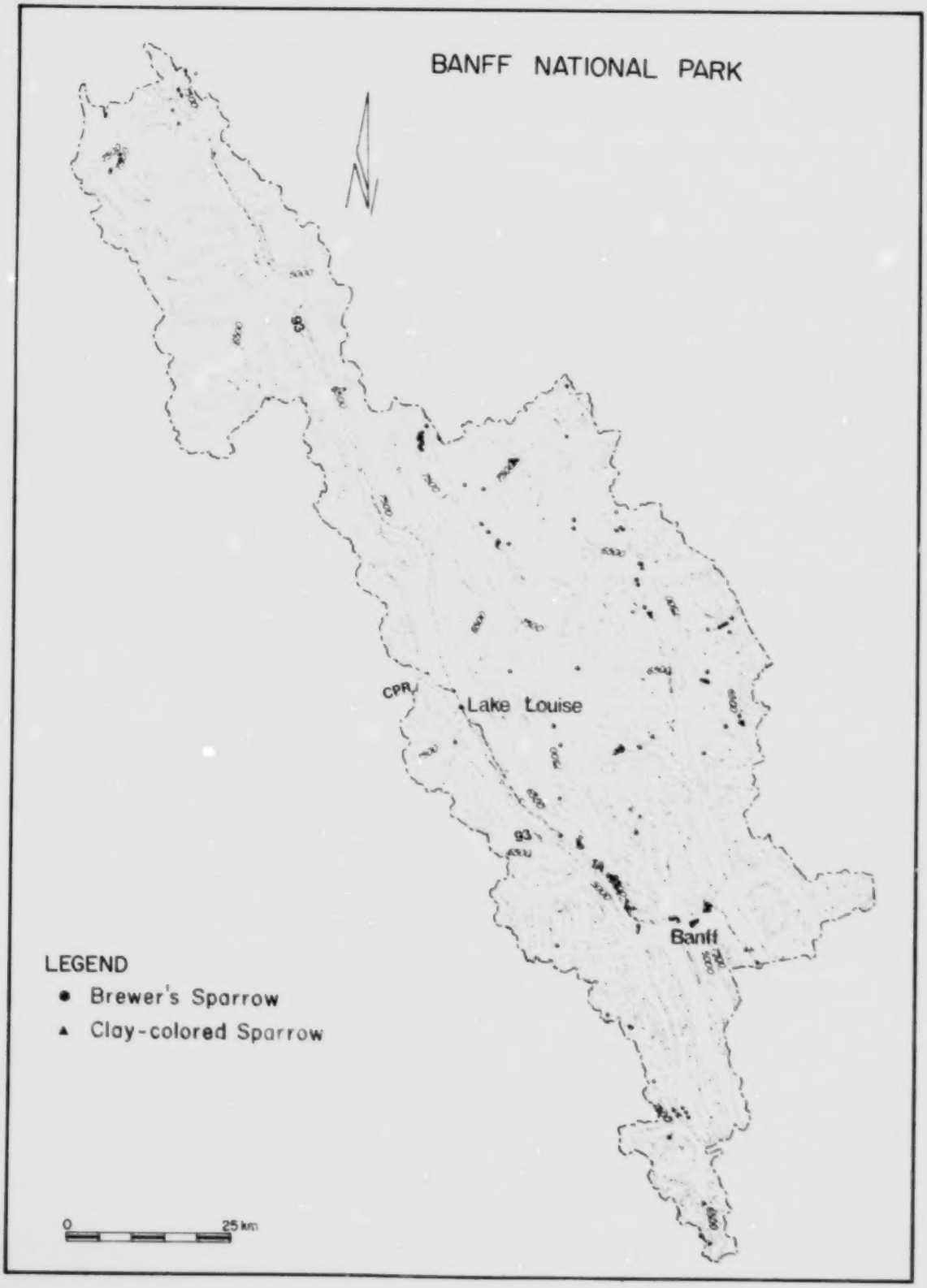
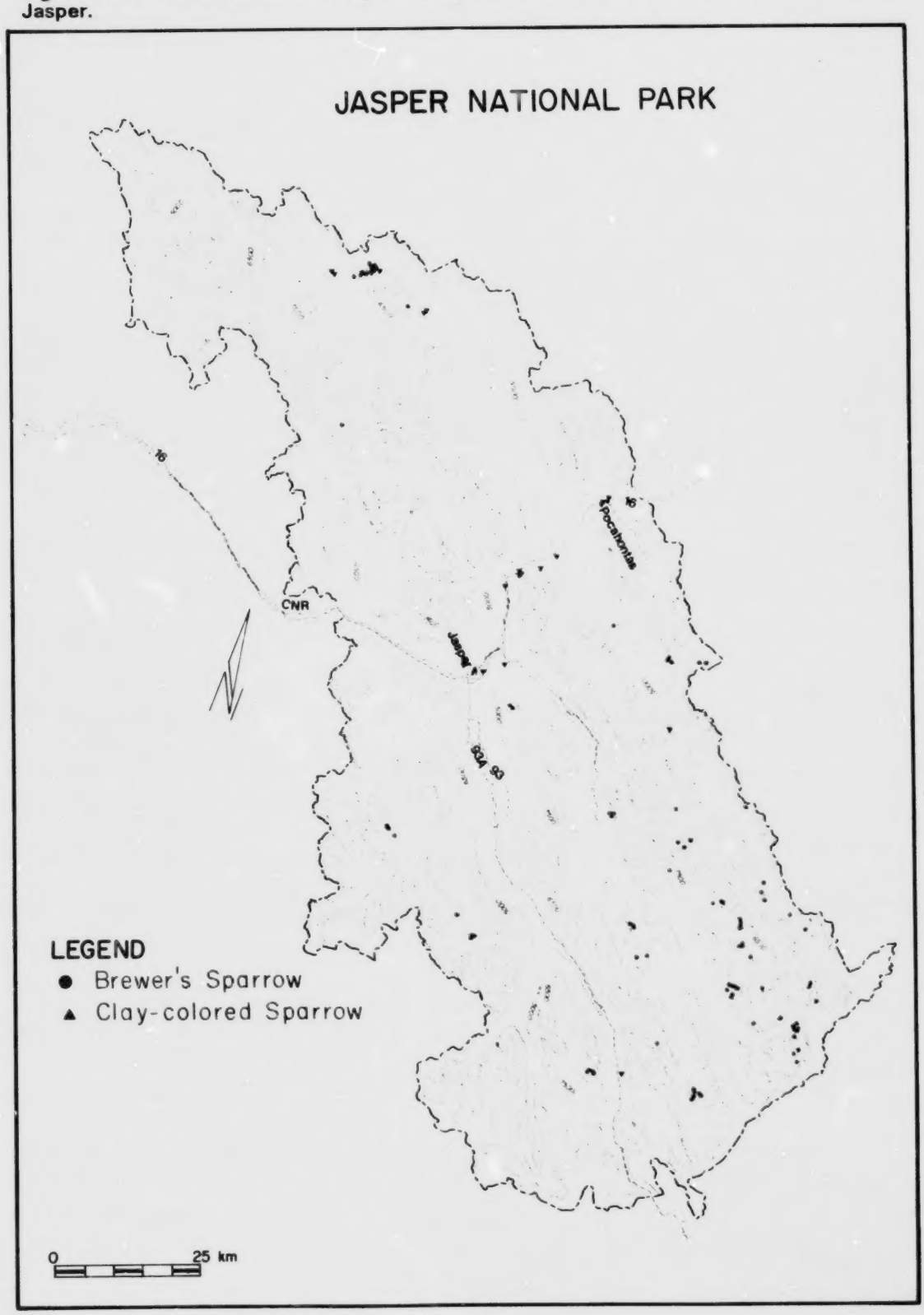


Figure 3.25. Distribution of Clay-coloured and Brewer's Sparrow observations in Jasper.



3.24, 3.25) where from 8 to 11 singing males have been recorded in one year; elsewhere there are records of only from 1 to 4 singing males.

There are no nest records. A nest was suspected on 25 June 1977 in the middle Bow River valley from the behavior of a pair (MED). Adults were seen carrying food, presumably to young, on 20 June (KAM) and 20 August (MED) 1977 in the lower Bow River valley.

Autumn migration occurs in August. A few remain into September, with the latest record being 14 September 1977 near Banff townsite. The maximum count is twelve on 12 August 1977, also near Banff townsite.

HABITAT

The Clay-coloured Sparrow occurs in the montane and lower subalpine ecoregions. It inhabits willow and birch shrubbery in meadows and forest/ grassland interfaces. There is a single record of a singing male on a shrubby avalanche slope in the upper subalpine ecoregion, in the Opal Hills.

BREWER'S SPARROW *Spizella breweri* **(B)** **BRSP**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: common resident
Autumn: uncommon migrant
Winter: not recorded

Brewer's Sparrow breeds in western North America from the southern Yukon and southwest Saskatchewan to California and New Mexico (Godfrey 1966). In Alberta one subspecies (*S.b. taverneri*) nests in the Rocky Mountains and another (*S.b. breweri*) nests in the dry southern prairies (Salt and Salt 1976).

Spring migration in Banff and Jasper probably occurs in late May and early June, however the earliest record is an individual on 1 June 1979 at the lower Brazeau River.

In the summer it occurs throughout both parks, but is least common in southern parts of Banff (Figure 3.24, 3.25). There are no Banff nest records, but there are several from Jasper. The earliest is a nest with 4 eggs on 25 June 1946 on Elysium Pass (Cowan 1955). The earliest fledged young was seen on 24 July 1977 in the north fork of the Brazeau River valley (DJK).

Autumn migration occurs in August. The latest record is 25 August 1978 in the Mistaya River watershed. The maximum count is a flock of twelve seen on 9 August 1979 in the Clearwater River valley. Immature Chipping Sparrows and Clay-coloured Sparrows are similar in appearance to Brewer's Sparrows and migrant flocks of *Spizella* sparrows should be checked carefully.

HABITAT

Brewer's Sparrow occurs primarily in the upper subalpine, but also to a limited extent the lower subalpine and alpine ecoregions. It inhabits willow and birch-willow shrubbery at timberline as well as subalpine fir krummholz and the edges of avalanche tracks. Highest densities in the breeding season are on hairy wild rye-junegrass-bearberry (H14) slopes (DI=13.62), subalpine fir-willow (S2) avalanche slopes (DI=8.63) and willow-dwarf birch-shrubby cinquefoil (S10) stands (DI=6.19).

HARRIS' SPARROW *Zonotrichia querula* **HASP**

STATUS AND DISTRIBUTION

Spring: not recorded
Summer: not recorded
Autumn: very rare visitor
Winter: not recorded

Harris' Sparrow breeds in north central North America in Mackenzie, Keewatin and northern Manitoba (Godfrey 1966). In Alberta it is an irregular migrant, more common in autumn than in spring (Salt and Salt 1976).

There is one Banff record: an immature was seen on 11 October 1977 near Banff townsite (Brunton et al. 1978). No Jasper records could be located; however Salt and Salt (1976) state that "in the Rocky Mountains it has been observed only at Exshaw and Jasper" and there is a report of one having been photographed near the Columbia Icefields at an unknown date (J.R. Salt, pers. comm.).

HABITAT

Harris' Sparrow inhabits "patches of stunted trees and woody shrubbery... (and) in migration and winter, various thickets, edges of woodland, and hedgerows" (Godfrey 1966). The Banff record was from a horse trail through a montane white spruce forest.

WHITE-CROWNED SPARROW *Zonotrichia leucophrys* **(B)** **WCSP**

STATUS AND DISTRIBUTION

Spring: common migrant
Summer: very common resident
Autumn: common migrant
Winter: very rare visitor

The White-crowned Sparrow breeds across northern North America from the Arctic coast south to northern parts of the provinces and, in the Rockies, to California and New Mexico (Godfrey 1966). It nests in extreme north and west Alberta, and in the Rockies and their foothills (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in late April and May, peaking in early and mid May. The earliest record is 20 April 1908 in Banff (Clarke and Cowan 1945). The maximum count is 143 counted on a roadside survey near Banff townsite on 6 May 1978. It usually occurs in flocks of less than 25. This is one of the most common spring sparrows.

In the summer it occurs throughout both parks. There are numerous nest records from both parks, the earliest being a nest with eggs found on 10 June 1943 near Spray River cabin. The earliest record of nestlings is 4 young in a nest on 26 June 1975 (JWW), and the earliest fledged young were seen on 3 July 1975 (DJK), both in the middle Bow River valley.

Autumn migration is in August and September, peaking in mid and late September. The latest record is 14 October 1978 at Vermilion Lakes (McIvor and McIvor 1980). The maximum count is 285 birds counted from 20 to 22 September 1945 around Jasper

townsite (Cowan 1955). Most often it occurs in flocks of less than 25.

There are three winter records: three birds in 1977 and one in 1978 on Banff Christmas bird counts, and one on 13 February 1967 at Banff townsite (Gordon 1975).

HABITAT

The White-crowned Sparrow occurs from the montane to the alpine, but is most common in the subalpine ecoregion. It is most abundant in shrubby meadows; highest densities occur in willow/cinquefoil (S8) (DI=39.44), dwarf birch-willow/kobresia (S9) (DI=29.15), willow-dwarf birch-shrubby cinquefoil (S10) (DI=16.66) and willow/timber oat-grass (S11) (DI=16.84) meadows. It is somewhat less abundant at the edges of water sedge-beaked sedge (H11) meadows (DI=15.13) and in shrubby Engelmann spruce-subalpine fir open forests (DI=8.15 to 11.06). These vegetation types occur on avalanche slopes, burns, active floodplains, subalpine valley floors, and timberline areas.

GOLDEN-CROWNED SPARROW *Zonotrichia atricapilla* **(B)** **GOSP**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: fairly common resident
Autumn: uncommon migrant
Winter: not recorded

The Golden-crowned Sparrow breeds from the south-central Yukon south to southern British Columbia and southwest Alberta (Godfrey 1966). In Alberta it nests in Banff and Jasper east to Mountain Park, but has not been recorded in Waterton Lakes National Park (Salt and Salt 1976).

Spring migration in Banff and Jasper occurs in May. The earliest record is 8 May 1974 at Banff townsite (Gordon 1975). Only one was recorded on any one occasion.

In the summer it occurs throughout Jasper and northern Banff, being more common in the Main Ranges than farther east (Figure 3.26, 3.27). Most Banff summer records are from the Alexandra River, upper North Saskatchewan River, and Nigel Creek watersheds, with up to 4 records in other watersheds to as far south as the Pipestone River. There are two Banff nest records, and several Jasper records. The earliest is a nest with newly hatched young found on 26 June 1946 at Elysium Pass (Cowan 1955). Fledged young were first seen on 27 July 1977 in the Alexandra River valley (GLH).

Autumn migration occurs in late July and August. There are two September records of single individuals. The latest record is 9 October 1950 at Pyramid Lake (Banfield, Jasper warden card). The maximum count is four on several occasions in August.

HABITAT

The Golden-crowned Sparrow breeds in the upper subalpine ecoregion and the lower edges of the alpine. It is most abundant in heather-everlasting (L5) meadows (DI=7.70), mountain marigold-globeflower (H9) meadows (DI=4.33), and mountain avens-snow willow-moss campion (H1) tundra (DI=3.48), where there are scattered clumps of stunted subalpine fir and Engelmann spruce.

Figure 3.26. Distribution of Golden-crowned and Fox Sparrow observations in Banff.

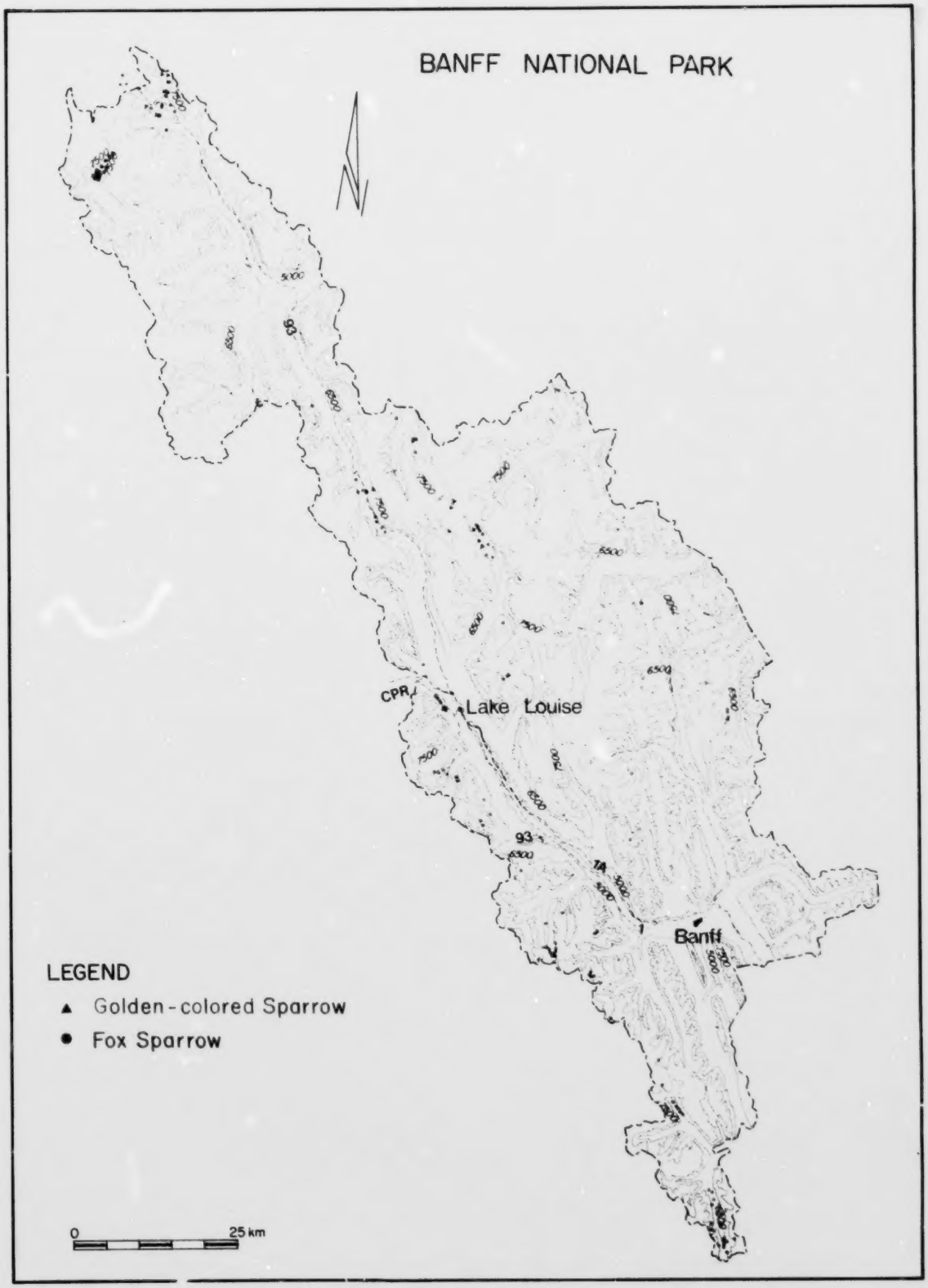
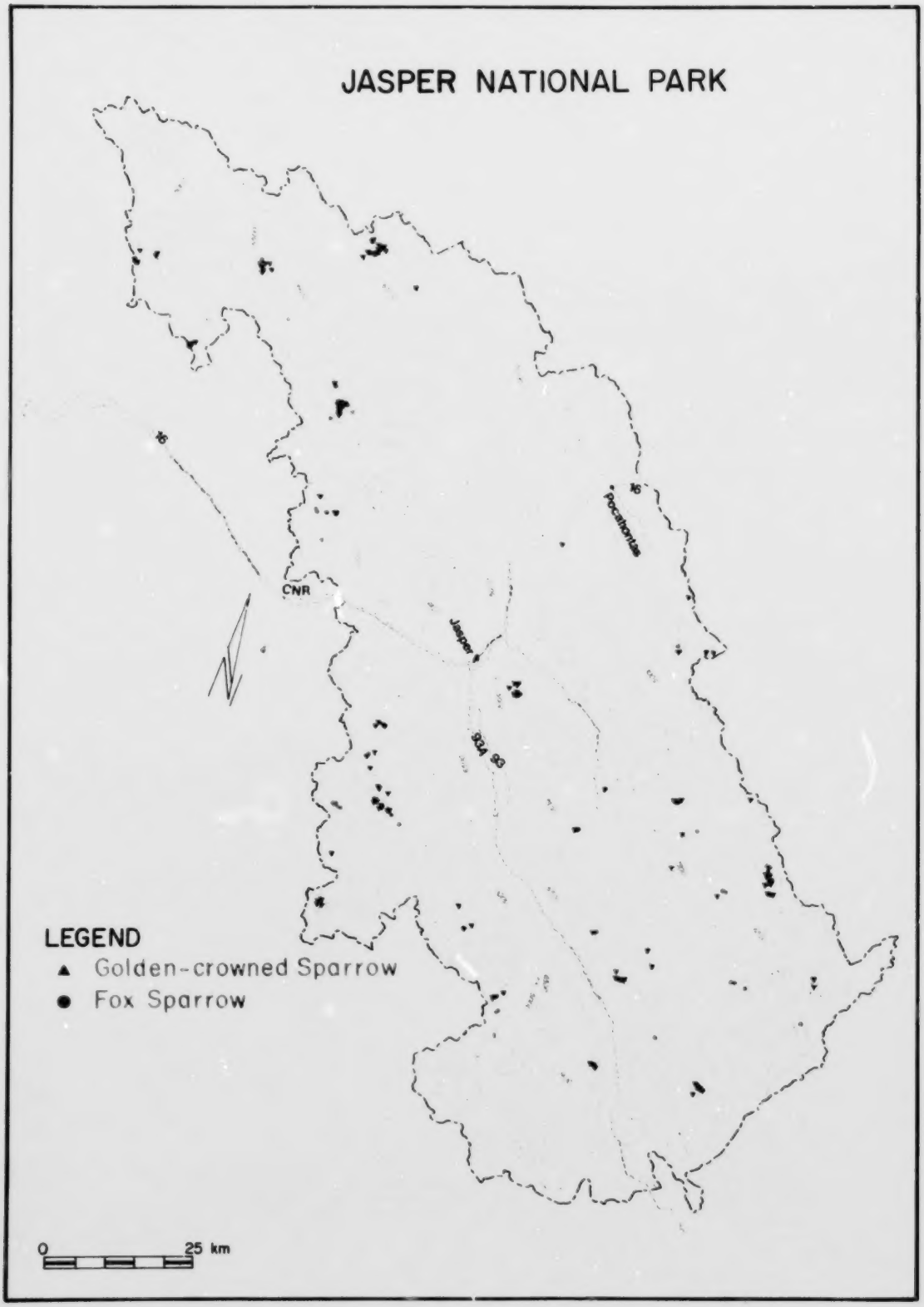


Figure 3.27. Distribution of Golden-crowned and Fox Sparrow observations in Jasper.



WHITE-THROATED SPARROW *Zonotrichia albicollis* **(b)** **WTSP**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: uncommon resident
Autumn: rare migrant
Winter: very rare visitor

The White-throated Sparrow breeds from the southeastern Yukon across Canada and south to the northeast United States (Godfrey 1966). It nests in north and central Alberta (Salt and Salt 1976).

Spring migration in Banff and Jasper is during May. The earliest record is 3 May 1975 at Vermilion Lakes (McIvor and McIvor 1980). The maximum count is 16 on 22 May 1944 at Willow Creek (Cowan 1955). Usually only individuals are observed.

White-throated Sparrows occur regularly only in the lower Athabasca River valley during the breeding season. There are only two Banff records of singing males: one on 14 June 1979 in the lower Red Deer River valley and one on 29 June 1980 near Cuthead Creek. At least ten singing males were recorded along the lower Athabasca River near Pocahontas from 8 to 11 June 1978 and two were heard on 11 June 1980. A pair that behaved as though they were near a nest was observed at least 3 times in June 1980 in the dunes near Talbot Lake and a male was singing adjacent highway 16 on the Jacques Creek fan on 19 June 1980.

This species is commonly associated with the boreal forest region and occurs regularly only where boreal elements reach into Jasper along the lower Athabasca River. Even here its abundance varies from year to year.

There are only 4 autumn records: two were seen on 24 September 1976 in the Valley of Five Lakes south of Jasper townsite, one was seen at Vermilion Lakes on 1 October and 12 November 1977 (McIvor and McIvor 1980), and two were seen on 9 October 1980 at Banff townsite (Banff warden card).

HABITAT

In the lower Athabasca River valley the White-throated Sparrow frequents willow thickets and the edges of balsam poplar-white spruce forest on montane river floodplains and dunes. On migration it occurs in brushy and disturbed areas, mostly in the montane ecoregion.

FOX SPARROW *Passerella iliaca* **(B)** **FOSP**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: fairly common resident
Autumn: uncommon migrant
Winter: not recorded

The Fox Sparrow breeds across northern North America from treeline south to northern parts of the provinces and in the western mountains to Colorado and California (Godfrey 1966). It breeds in the northern half of Alberta and in the Rockies (Salt and Salt 1976).

Spring migration in Banff and Jasper is in late April and May. The earliest record is 22 April 1943 at Pyramid Lake (Cowan 1955). The maximum count is three on 16 May 1977 near Bow Summit.

In the summer it occurs throughout both parks (Figure 3.26, 3.27). There are no nest records. An adult was seen carrying nesting material on 29 June 1978 at the Pipestone River (KAM), and one was seen with 3 fledged young on 24 July 1977 in Poboktan Pass (JRS).

Autumn migration is in late August and September. The latest record is 4 November 1980 on the Fenland Trail in Banff National Park. The maximum count is three on 19 August 1978 in the Siffleur River valley.

HABITAT

The Fox Sparrow occurs from the lower subalpine to the alpine ecoregion, being most abundant at timberline in the upper subalpine ecoregion. It inhabits Engelmann spruce-subalpine fir open forest and edges at treeline and along avalanche slopes. Highest densities are in open subalpine larch/heath forest forest (DI=8.87), Engelmann spruce-subalpine fir/valerian-fleabane (09) forest (DI=5.76), subalpine fir-willow (S2) avalanche scrub (DI=3.25) and Engelmann spruce-subalpine fir/heather (010) forest (DI=2.49).

LINCOLN'S SPARROW *Melospiza lincolnii* **(b)** **LISP**

STATUS AND DISTRIBUTION

Spring: fairly common migrant
Summer: very common resident
Autumn: fairly common migrant
Winter: not recorded

Lincoln's Sparrow breeds across North America from near treeline south to Maine and Minnesota and, in the western mountains, to California (Godfrey 1966). It nests in the northern half of Alberta and in the Rockies and their foothills (Salt and Salt 1976).

Spring migration in Banff and Jasper is during May and peaks in mid and late May. The earliest record is 29 April 1972 at Banff townsite (Gordon 1975). The maximum count is 21 on 17 May 1976 in the middle Maligne River drainage. Most observations are of individual or pairs.

In summer Lincoln's Sparrow occurs throughout Banff and Jasper and is most common in the middle Bow River and lower Athabasca River valleys (Figure 3.28, 3.29). No nests have been recorded but an adult was seen carrying nesting material on 23 June 1978 in the lower North Saskatchewan River valley and fledged young were seen on 23 July 1971 at Echo Creek (Gordon 1975) and 29 July 1977 near Brazeau Lake. This species is one of Banff and Jasper's most common sparrows in summer.

Autumn migration is during August, with only small numbers remaining into in September. The latest record is one seen on 8 October 1979 at Banff townsite (McIvor and McIvor 1980). Flocks usually contain fewer than 10 birds.

HABITAT

Lincoln's Sparrow is commonest in the montane and lower subalpine ecoregions but occurs occasionally in the upper subalpine. It inhabits wetlands with emergent sedge

Figure 3.28. Distribution of Lincoln's and Song Sparrow observations in Banff.

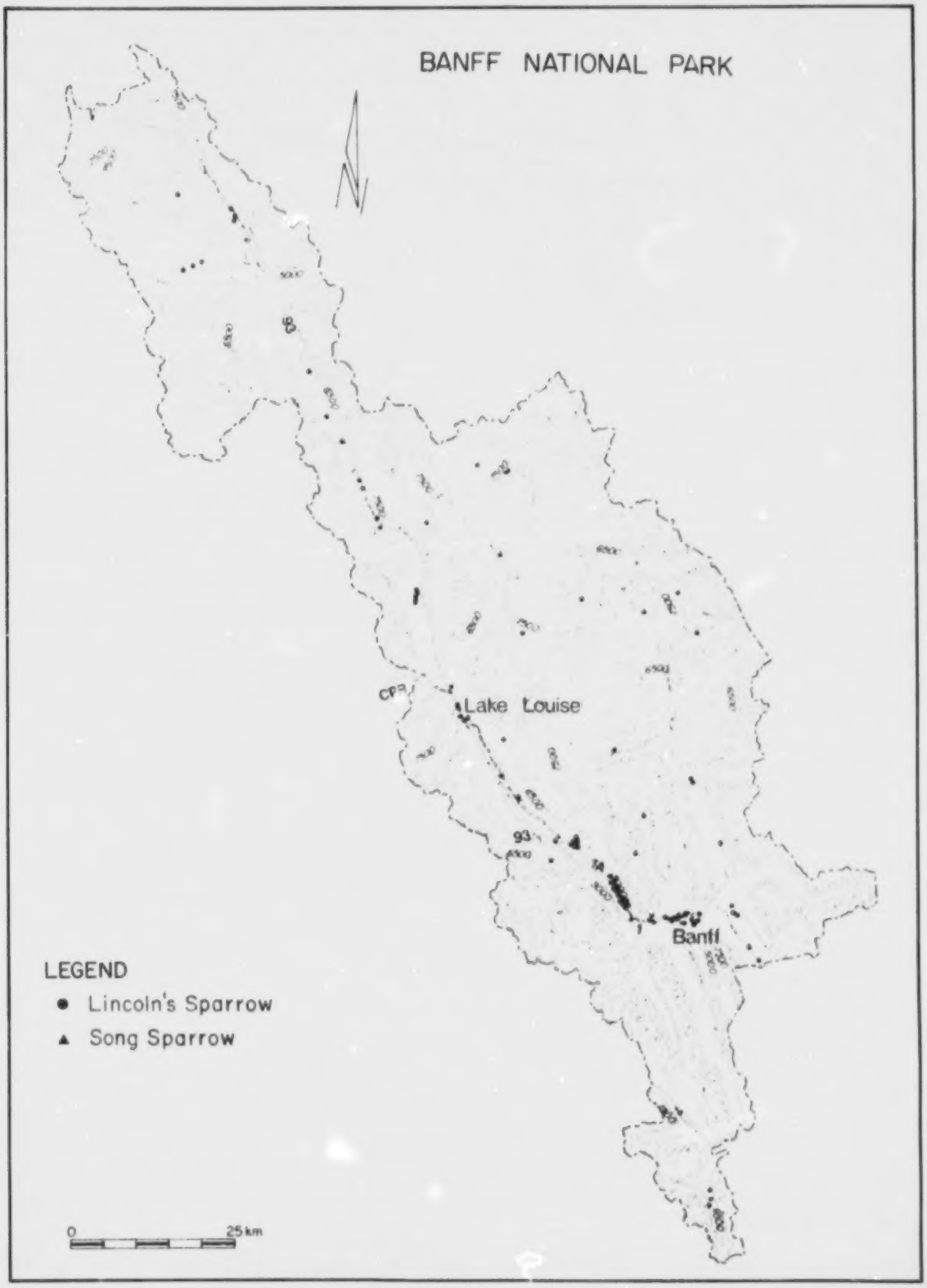
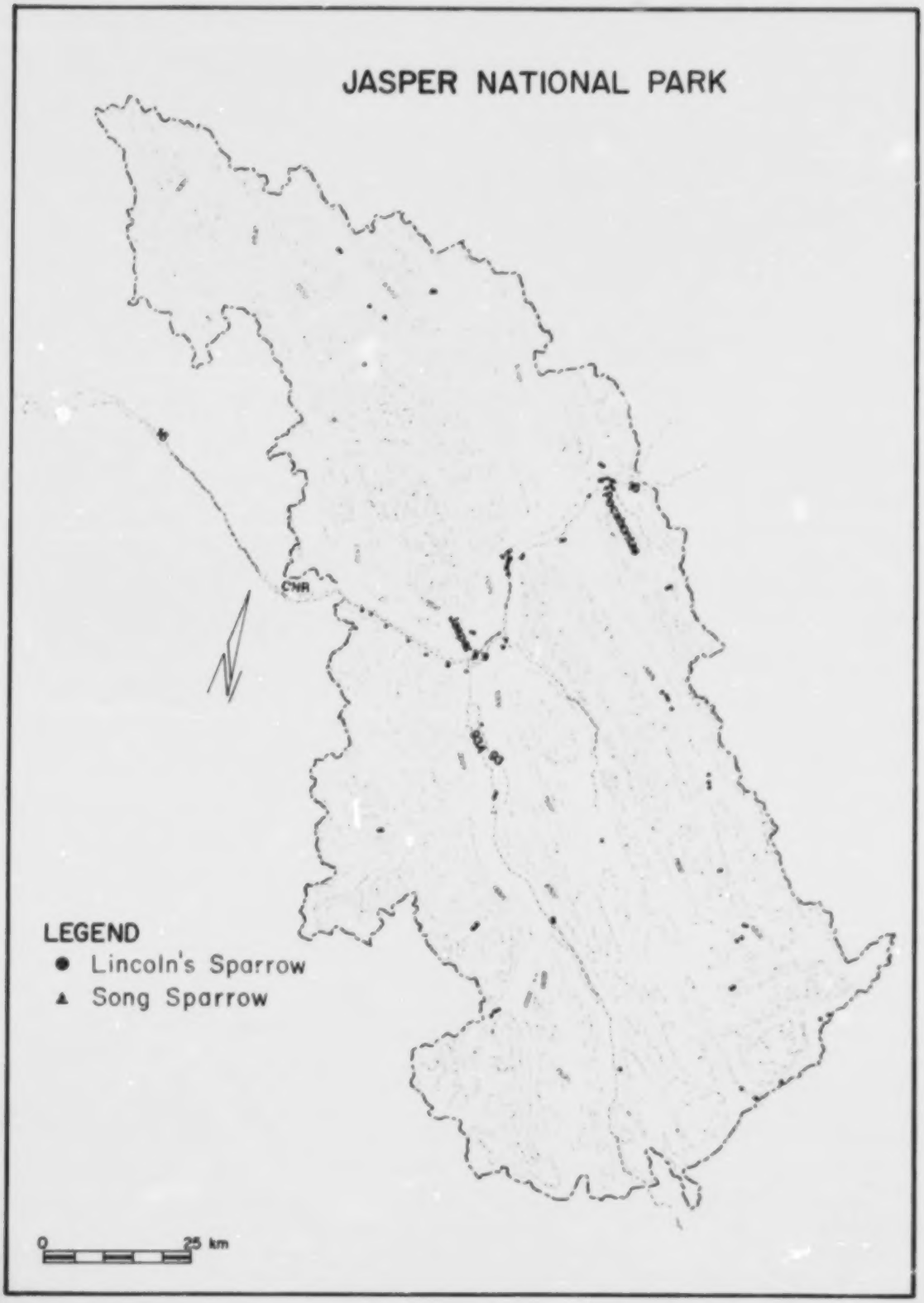


Figure 3.29. Distribution of Lincoln's and Song Sparrow observations in Jasper.



vegetation and clumps of willow shrubbery, as well as forest edges bordering lakes, bogs and slow streams. The highest densities of this species during the breeding season are in dwarf birch-shrubby cinquefoil/needlerush (S3) wetlands (DI=35.53), water sedge-beaked sedge (H11) meadows with scattered willow clumps (DI=21.54), and willow/timber oatgrass (S11) meadows (DI=10.53).

SWAMP SPARROW *Melospiza georgiana* **SWSP**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: very rare visitor
Autumn: very rare migrant
Winter: not recorded

The Swamp Sparrow breeds from western Mackenzie and northeastern B.C. across the boreal region of North America to Newfoundland and Maine (Godfrey 1966). It nests locally in northern and central Alberta (Salt and Salt 1976).

There are three spring records of this species. On 29 May 1976 there were seven seen in the Banff townsite area and one in the lower Athabasca River valley (GLH, DJK). On 28 May 1978 one was recorded near Banff townsite. Salt and Salt (1976) say it has been recorded in spring near Lake Louise.

A male was reported singing in a willow-bordered wetland south of Edith Lake on 28 June 1978 (JRS) but there are no sight records during the breeding season.

There is one autumn record: an individual was seen on 27 September 1977 near Banff townsite (KAM).

HABITAT

The Swamp Sparrow inhabits "... margins of ponds, lakes, and streams with tall emergent vegetation such as cattails, or woody shrubbery like alder and willow (as well as) freshwater marshes with tangles of vegetation... " (Godfrey 1966). In Banff and Jasper all records have been in the montane ecoregion.

SONG SPARROW *Melospiza melodia* **(B)** **SOSP**

STATUS AND DISTRIBUTION

Spring: uncommon migrant
Summer: fairly common resident
Autumn: uncommon migrant
Winter: very rare visitor

The Song Sparrow breeds across North America from the southern half of Canada to Mexico except in the extreme southeast U.S.A. (Godfrey 1966). It nests throughout northern and central Alberta, locally in the prairies, and in small numbers in the Rockies (Salt and Salt 1976).

The Song Sparrow is one of the earliest spring migrants in Banff and Jasper. Spring migration begins in late March and lasts into late May. The earliest record is an individual at Vermilion Lakes on 22 March 1978 and the maximum count is seven on 17 May 1977 in the same area.

In the summer it is most common in the lower Bow River valley and occurs in much smaller numbers in the lower and middle Athabasca River valleys. There are two records from the south fork of the Brazeau River valley and one from each of the Bryant Creek, Clearwater River, upper North Saskatchewan River, lower Red Deer River and Sunwapta River valleys during the breeding season (Figure 3.28, 3.29). There are no Banff nest records but a nest with 5 young was found near Jasper Lake on 26 June 1976 (GLH) and newly-fledged young were seen in the Miette valley on 30 June 1944 (Cowan 1955).

Autumn migration is in August and September. The latest record is 6 October 1979 (McIvor and McIvor 1980) and the maximum count is 10 on 2 August 1977, both at Banff townsite.

There are 2 winter records: two were seen on 16 December 1978 at the Jasper sewage lagoon (KVT) and one was recorded on 8 January 1977 near Vermilion Lakes (McIvor and McIvor 1980).

HABITAT

The Song Sparrow occurs in the montane and, occasionally, lower subalpine ecoregions. It inhabits shrubby alluvial areas. On migration it frequents a variety of shrubby and disturbed areas.

LAPLAND LONGSPUR *Calcarius lapponicus* **LALO**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: not recorded
Autumn: uncommon migrant
Winter: not recorded

The Lapland Longspur is a circumpolar species, breeding in North America in tundra areas north of the treeline (Godfrey 1966). It is a spring and autumn migrant throughout Alberta but is less common in the Rockies (Salt and Salt 1976).

In Banff and Jasper this species has been seen more often in autumn than in spring. There is only one spring record: nine were seen from 19 to 21 May 1903 (Clarke and Cowan 1945).

Autumn migration is during September and October. The earliest record is a specimen collected on 31 August 1917 at Mount Edith Cavell (Cowan 1955) and the latest is a female on 31 October 1968 at Windy Cabin in the Panther River valley (Gordon 1975). There have only been 5 records since 1970, with the maximum count being 25 on 18 September 1975 in the middle Bow River valley (DJK). On 21 and 22 September 1945 at least 415 Lapland Longspurs were seen at Jasper townsite (Cowan 1955).

HABITAT

Lapland Longspurs occur from the montane to the alpine on migration, in a variety of open habitats including alpine meadows (4 of 6 records), roadsides (Godfrey 1966) and

wetlands (Godfrey 1966).

CHESTNUT-COLLARED LONGSPUR *Calcarius ornatus* **CHLO**

STATUS AND DISTRIBUTION

Spring: very rare migrant
Summer: not recorded
Autumn: not recorded
Winter: not recorded

The Chestnut-collared Longspur breeds in central North America from the southern prairie provinces south to Colorado and Minnesota (Godfrey 1966). It nests locally on the prairies of southeastern Alberta, west to Calgary (Salt and Salt 1976).

There is 1 Banff records: a male was seen on 25 April 1943 in the middle Bow River valley (Clarke and Cowan 1945). None have been seen in Jasper.

HABITAT

The Chestnut-collared Longspur inhabits "short-grass plains and prairies" (Godfrey 1966). The Banff record is from a wet meadow in the lower subalpine ecoregion and a shrubby montane grassland.

SNOW BUNTING *Plectrophenax nivalis* **SNBU**

STATUS AND DISTRIBUTION

Spring: rare migrant
Summer: not recorded
Autumn: rare migrant
Winter: common resident

The Snow Bunting is circumpolar. In North America it breeds on the arctic islands and coasts south to central Keewatin (Godfrey 1966). It is a winter visitor throughout central and southern Alberta, including the Rockies (Salt and Salt 1976).

In Banff and Jasper it is a winter resident, arriving in October and leaving in April. Autumn migration occurs in October and November. The earliest record and maximum count is 35-50 birds on 7 October 1967 in the lower Cascade River valley (Gordon 1975).

Wintering flocks occur primarily in the lower and middle Bow River and lower and middle Athabasca River valleys. Here flocks of over 100 birds are sporadically seen. The largest flock, about 300, was seen on 10 February 1978 in the lower Bow River valley (GLH). Individuals and flocks of up to 25 have been recorded at several other locations, most notably near North Saskatchewan River Crossing. There are no records from north of the Miette and lower Athabasca Rivers.

Spring migration occurs in March and April. The latest record is 29 April 1913 in Banff (Clarke and Cowan 1945). The latest recent record is 5 April 1977 at Vermilion Lakes (Bow Valley Naturalists 1978). The maximum count during these two months is a

flock of 50 on 4 March 1979 in the lower Athabasca River valley.

HABITAT

The Snow Bunting winters primarily in the montane ecoregion; smaller numbers occur in the lower subalpine. It is most common along roadsides and railways, but is also found in grasslands and frozen wetlands.

3.3. MAMMALS

Small Mammals

Natural history notes, Canadian distributions, common names and scientific names are from Banfield (1974) unless otherwise noted. The scientific name for the dusky shrew, *Sorex monticolus*, is after Hennings and Hoffman (1977).

Small mammal specimens collected in Banff and Jasper National Parks prior to this project may be found in the National Museum of Canada, the Royal Ontario Museum of Zoology, the University of Alberta Zoology Museum and the Banff Museum. Specimens collected during the present project have been stored at the Provincial Museum of Alberta, the Royal Ontario Museum of Zoology and the National Museum of Canada.

MASKED SHREW *Sorex cinereus* **MASH**

STATUS AND DISTRIBUTION

The masked shrew is found throughout Canada with the exception of the arctic islands.

This shrew occurs throughout Banff and Jasper National Parks in a wide range of moist habitats (Banfield 1958, Soper 1970, present study). It was the most common species caught in 21 pitfall trap lines (184 individuals; 45% of total catch) but was poorly sampled by snap traps (105 individuals; 2.8% of total catch). Five or more snap trap lines in each of the following watersheds failed to capture a masked shrew: Astoria River, Healy Creek, upper Brazeau River, upper and lower Rocky River, Panther River and Nigel Creek. Shrew tracks were, however, found in winter in the snow.

HABITAT

Generally, masked shrews inhabit moist forests of various types (Moore 1949) and wet grass-sedge meadows (Negus and Findley 1959). They tolerate standing water in their habitat (Getz 1961). In the mountain parks, they occur from the montane (33 caught; average catch/100 trap nights in ecosites with masked shrews=0.46), through the lower subalpine (60 caught; average catch/100 T.N.=0.38) to the upper subalpine (12 caught; average catch/100 T.N.=0.27). Edworthy (1978) reported a shrew, probably this species, on the Wapta Icefield. Masked shrews occupy closed forest, and shrubby habitats, especially in moist sites with a well-developed herb layer. They are uncommon in grassland and other habitats where the herb layer is the only cover. Mesic to hygric ecosites support the highest densities of shrews. All habitats with high densities of shrews are drainage class 3 or higher. The highest capture rate in pitfall traps (16.33/100 trap nights) occurred in a montane wetland of drainage class 5 to 7. Tree cover in masked shrew habitat may consist of white spruce, Engelmann spruce, lodgepole pine or aspen. Shrubby habitats are dominated by juniper, willow, shrubby cinquefoil, dwarf birch and alder. Grasses may be common in the herb layer and include *Elymus*, *Festuca*, *Koeleria*, *Poa*, *Calamagrostis* and *Bromus* species.

A snap trap catch per 100 trap nights of 0.001 to 0.193 is considered low, 0.194 to 0.499 medium and 0.500 to 1.730 high. Pitfall trap data were used to adjust the classification of ecosites and vegetation types in the wildlife legend (volume I).

LIFE HISTORY

This shrew has a lifespan of 14 months from the time of birth until the following summer, but individuals have lived as long as 23 months (Buckner 1966). In the Jasper and Talbot Lakes area, there were six shrews that had very well-worn teeth. These animals could have been living in their third summer. Over-wintered females have two or more litters during the breeding season (April to late September). Females born in spring may mature in four months, give birth to a litter and die before winter but most young females breed for the first time in the following spring. In a Manitoba study, litter size ranged from five to nine, with a mean of 6.8 embryos (Buckner 1966). Forsyth (1976) recorded a mean litter size of 6.7 in nine litters in Ohio. In the present study, embryo counts revealed a lower mean litter size of 5.5 (S.D.=1.0, N=4) and there were two placental scar counts, both showing four scars.

Shrews are active all winter, hunting in burrows under snow. Their food consists mainly of insects, including overwintering bees (Bland 1965), but they also eat salamanders, young mice, centipedes, worms, molluscs, sowbugs and vegetable matter. Feeding habits change seasonally from an insectivorous summer diet to a largely granivorous winter diet (Criddle 1973).

Shrews are active periodically throughout the day and night and therefore are vulnerable to hawks, owls, snakes and weasels.

MANAGEMENT CONSIDERATIONS

Shrews inhabit areas having moist microclimates. Such habitat may be lost if drainage is altered or if low, dense vegetation is destroyed with the result that atmospheric moisture or humidity declines near the soil. Lush herb and shrub cover adjacent to ponds or streams is very productive shrew habitat. Because of their insectivorous diet, shrews are important predators on forest insects and are vulnerable to insecticides.

DUSKY SHREW *Sorex monticolus*

STATUS AND DISTRIBUTION

The dusky shrew is found in the mountains and prairies of western North America from the southern United States to Alaska.

This shrew occurs widely at low densities throughout Banff and Jasper. Soper (1970) sampled in 20 areas in Jasper and found this species in 11 areas, describing it as being either extremely scarce or absent. Although as many as six dusky shrews were caught on a single snap trap line or pitfall line during the present study, most (31 0f 41) of traplines that produced dusky shrews caught only one or two animals. There were 26 dusky shrews caught in pitfall traps and 54 caught in snap traps (6% of pitfall trap and 1.4% of snap trap total captures respectively). The average catch of dusky shrews per 100 trap nights was 0.09 animals in snap traps. Seven or more traplines in each of the following watersheds failed to capture any dusky shrews: Astoria River, middle Athabasca River, Cairn River, Mistaya River, lower Spray River and Sunwapta River.

HABITAT

In ecosites where dusky shrews were captured, the average catch in snap traps per 100 trap nights was 0.35 in the montane, 0.26 in the lower subalpine, 0.40 in the upper subalpine and 1.75 in the alpine. Moisture conditions of these ecosites are mesic to hygric and dominant tree cover includes white spruce, Engelmann spruce, lodgepole pine, subalpine larch, subalpine fir, trembling aspen and willow. The understories are usually lush and dominated by herb species, and the soils are derived from fluvial, till and colluvial materials. Negus and Findley (1959) found this shrew in similar habitats, including

aspen communities, streamside willows, lodgepole pine forest, grass-forb meadows, wet meadows and spruce-fir forest.

A snap trap catch per 100 trap nights of 0.001 to 0.178 is considered low, 0.179 to 0.541 medium and 0.542 to 1.749 high. Pitfall trap data were used to adjust ecosite importance rankings in the wildlife legend (Map Supplement) and ecosite accounts (below).

LIFE HISTORY

This species exhibits activity peaks throughout the day and is active all year. Mating begins in March and pregnant females have been found from April to early August. Overwintered females usually have two litters but may have three litters over their 16-month (maximum) lifespan and young females may have their first litter in the summer of birth. In a Montana study, mean litter size was 6.4 with a range of two to nine (Clothier 1955). Counts of embryos and placental scars in the present study revealed a mean litter size of 5.75 (S.D.=2.22, N=4).

The main food source is insects. Earthworms, molluscs, spiders and vegetable matter are also eaten. Clothier (1955) did not find a significant variation in food types eaten throughout the year.

Predators of this species are similar to those of the masked shrew.

MANAGEMENT CONSIDERATIONS

Comments concerning the masked shrew (above) also apply to this species.

WATER SHREW *Sorex palustris* **WASH**

STATUS AND DISTRIBUTION

The water shrew occurs in all provinces of Canada and its range reaches the southern Yukon Territory and the south-western Northwest Territories. It does not occur on the island of Newfoundland, nor in the prairie region.

This species is very rare but is probably widespread in Jasper and Banff National Parks. Soper (1970) trapped one water shrew in traps set along streams in 19 areas of Jasper National Park. Although few of the 330 snap trap lines set during the present project were in water shrew habitat, four specimens were collected (2 from the middle Bow valley, 1 from the Johnston Creek watershed and 1 from the upper Rocky River watershed). One water shrew was sighted in the upper Maligne River valley. With only five records, distribution is difficult to assess. The National Museum of Canada has three specimens collected around Jasper townsite, three specimens collected around 7-mile cabin on the Spray River, two specimens collected along the Bow River between Lake Louise and Eisenhower Junction and one specimen from the Redearth Creek area. The Royal Ontario Museum of Zoology has two water shrew specimens from the Healy Creek area and one from the Moraine Lake area. The University of Alberta Zoology Museum has specimens from Moraine Lake, Maligne Lake and Little Heaven. Collectively, these records indicate that Water shrews occur in all parts of Banff and Jasper.

HABITAT

Water shrews occur from the montane to the upper subalpine. Specimens captured during this project come from subxeric shrubby habitat and mesic to subhygric, shrubby, open forest habitat. Notes accompanying museum specimens suggest an association with streams flowing through mossy, spruce-fir forests. Conaway (1952), in

the mountains of Montana, found water shrews along fast, cold mountain streams having banks with crevices and overhanging ledges. Two habitats that include streams are known to support Water shrews in Banff and Jasper, one being a shrubby open forest habitat and the other being a subalpine coniferous forest habitat. Habitat requirements of Water shrews cannot be described here in greater detail because of different trapping strategies. The strategy of the present project is to sample uniform vegetation cover with the result that stream courses and other restricted habitat types and ecotones are not sampled. The strategy of museum collectors is to trap in habitats thought to be most productive of the target species and this results in large samples of animals from restricted habitats. Water shrew habitats can be said to have flowing water and generally cool temperatures in common while cover can vary from lush shrubbery to Engelmann spruce and subalpine fir with moss ground cover.

LIFE HISTORY

The water shrew has periods of activity throughout the twenty-four hour period and is active throughout the year. Pregnant females have been found from April to August and overwintered females may have two or three litters during the breeding season. Young females may breed in their first summer. There are usually six young per litter but the range in litter size is from five to eight (Conaway 1952). Surviving from one summer to the next, the lifespan is just over a year long.

The diet is primarily insects, especially the aquatic larvae of stoneflies, caddisflies and mayflies. Buckner and Ray (1968) found that water shrews living in a larch bog fed mainly on ground beetles (Carabidae). Small fish, fish eggs and planarians are also eaten. Buckner (1970) observed the capture of a fish and noted that the prey was "apparently weak or injured".

MANAGEMENT CONSIDERATIONS

Comments relative to the masked shrew are also applicable to the water shrew. Loss of habitat may result from changes in stream flow rates. Pollution of water courses used by this species would influence the availability of aquatic insects. Heavy foot traffic along favored streams would lead to reduced shrew numbers through trampling of vegetation and compaction of soil.

PIGMY SHREW *Microsorex hoyi* **PISH**

STATUS AND DISTRIBUTION

Distribution of the pigmy shrew in Canada extends from the Atlantic Provinces (except for the island of Newfoundland) west to central British Columbia and the central Yukon Territory.

Pigmy shrews are rare in Banff and Jasper National Parks. Very intensive trapping directed at this species would probably reveal a patchy distribution and low numbers. Two specimens were collected in the middle Bow River valley during the present project. No historical specimens from Banff and Jasper are stored in museums but the National Museum of Canada has one specimen taken in the foothills east of Banff National Park near Sundre. Soper (1970) lists the pigmy shrew as a hypothetical species in Jasper National Park. With only two records from the parks, a description of the distribution of pigmy shrews within the parks is not possible. While the capture of the two specimens in very different habitats would suggest that pigmy shrews could occur throughout the parks at least in these habitats, both shrews were taken in pitfall traps in the middle Bow valley. Pigmy shrews probably occur in the Athabasca and Bow valleys in very low numbers and may be rare or absent elsewhere in the parks.

HABITAT

Specimens have been collected from a montane wetland with white spruce forest at 1380 m. elevation and a glacial till slope with lodgepole pine–spruce forest at 1560 m. elevation. Banfield (1974) described this shrew as occurring in grassy meadows in coniferous forest, in sphagnum bogs or in the shrubby borders of bogs and wet meadows. Although usually found in mesic habitats, pigmy shrews can inhabit dry areas if water is available. Long (1972) believes that *Microsorex* inhabits wet habitats in spring but, as numbers increase in summer, they disperse into drier habitats.

LIFE HISTORY

Little is known about the pigmy shrew. It remains active throughout the twenty–four–hour period and throughout the year. Litter size ranges from three to eight. Pregnant females have been found from late June to early August. Overwintered females are thought to have only one litter per year (Long 1972).

Food sources include insects and carcasses of small mammals.

MANAGEMENT CONSIDERATIONS

Comments made about the masked shrew also apply to the pigmy shrew. Given the scarcity of specimens taken in the parks, future captures should be deposited in a museum and detailed habitat descriptions should be collected. The two capture sites, Healy Creek backswamp and the lower end of the Bourgeau Lake trail, should be considered critical to this very rare species and protected from disturbance.

LITTLE BROWN BAT *Myotis lucifugus* **LIBA**

STATUS AND DISTRIBUTION

The little brown bat, the most common bat in Canada, is found from California to central Alaska eastward to the Atlantic coast from southern Labrador to Georgia.

In Banff and Jasper National Parks, the little brown bat is generally uncommon. It occurs in the lower valleys of the Front Ranges and is locally fairly common in the lower and middle Bow valley, the townsite areas of both parks and the lower Athabasca valley. In Banff National Park, little brown bats were detected in the Muleshoe area (1–2), Pilot Pond area (1–2), around Forty Mile Creek near Banff townsite (1) and in the Vermilion Lakes area (1–3) in mid–August 1980 and at Lake Minnewanka (6) and the golf course (5) in May 1980. In August 1980 in Jasper National Park, little brown bats were recorded at the Park horse corrals (1), by the bridge over the Athabasca River (1), around street lights in the townsite (1–2), over the lower Miette River (1–3), near the Southesk Warden Cabin (4), Beauvert Lake (2), Edith Lake (1–2) and Cottonwood Slough (21). During this project, seven dead bats were removed from an attic in Banff townsite, ten females were caught at the Baker Creek bungalows and seven lactating females were netted at their nursery colony in the Johnston Creek Staff House. Banfield (1958) found the little brown bat to be "common in the Bow valley" and found "several summer colonies in the attics of Banff Houses and in tourist lodges along the highways". Soper (1970) described any bat species in the mountains as "uncommon, capriciously distributed, and seldom sighted". Soper probably underestimated the number of bats in the Athabasca valley, while numbers of bats in the Bow valley may have changed little since Banfield's assessment.

HABITAT

Summer distribution of bats in the mountains includes the montane and lower subalpine ecoregions. Although Soper (1970) suggested that bats could be found at

altitudes up to 2100 m, the highest bat record in this project was at 1620 m. along the Southesk River. Searches for day roosts, nursery colonies and hibernation sites were unsuccessful. Feeding habitats include quiet lakes and ponds, open lodgepole pine, spruce or Douglas-fir forest and forest clearings. Little brown bats also feed around street lights of the townsites. Buildings with accessible attics remain the most probable location for nursery colonies and perhaps day roosts but questioning of local residents revealed only single individuals.

LIFE HISTORY

The little brown bat is a colonial species. Sexes are segregated during the summer as females tend their young in nursery colonies. In autumn, both sexes move to caves where they spend the winter in dormancy. Cave temperatures falling below about 5°C may cause mortality in dormant bats because the bats do not maintain a specific minimum body temperature. The scarcity of caves and the presence of ice in many probably accounts for the scarcity of bats in Banff and Jasper. During the winter, bats may occasionally wake up and move around the cave. Mating occurs during these breaks in dormancy or before the bats enter the caves in autumn. Ovulation occurs in April or May and the single young is born between mid-May and early July. In central Alberta, females do not bear young as yearlings (Schowalter et.al. 1979).

Being nocturnal, with peaks of feeding activity after sunset and before sunrise, bats are most susceptible to nocturnal predators. The great horned owl is probably the main predator in the mountain parks. Shrews have been reported entering caves and preying on bats resting in low, accessible roosts (Banfield 1974).

Foods of the little brown bat are the soft-bodied flying insects such as moths, beetles and bugs.

MANAGEMENT CONSIDERATIONS

Numbers of bats in the mountain parks appear to be low. Scarcity of old buildings and exclusion from potential nursery sites in other buildings may explain the present low numbers. The abundance of a colonial bat species is also related to the availability of roosting sites (Humphrey and Cope 1976). Schowalter et.al. (1979) found 75% of colonies in central Alberta were in occupied buildings and many of the remaining colonies were in unoccupied buildings. Bat numbers may also be limited by the cold mountain climate. Temperature may be a problem restricting the number of nursery colony sites, the growing season, foraging activity and the numbers of prey species. Natural locations used by bats for roosts, nursery colonies or for overwintering should be protected. None are presently known.

The subspecies *M. l. pernox* was described from specimens collected at Henry House in Jasper National Park. Specimens of bats collected in the mountains are few in number and therefore any available specimens should be deposited in a museum.

Bats are widely feared because of myths and their roles in transmitting rabies; for this reason and because of their visibility when feeding around street lights and their sonar capabilities, bats lend themselves well to interpretation to park visitors.

KEEN'S BAT *Myotis keenii* **KEBA**

STATUS AND DISTRIBUTION

The Keen's bat may occur in Jasper National Park. Specimens, stored in the Provincial Museum of Alberta, were collected in Cadomin, east of Jasper. Schowalter (1979) describes this bat as being widely distributed in northern and central Alberta. As the little brown bat is about the same size and color as this bat, the presence of the Keen's bat within park boundaries may have been overlooked. As this is a solitary species which forages in forest openings and over rivers rather than around townsites, chances that this species will be observed are limited.

During this project, there were no Keen's bats caught or detected by echolocation calls with ultrasonic microphones.

LONG-EARED BAT *Myotis evotis* **LEBA**

STATUS AND DISTRIBUTION

In summer, the long-eared bat occurs throughout western United States from California in the south to the Canadian border in the north. The summer range extends into Canada in southwestern Saskatchewan, southern Alberta and southern British Columbia. It appears to be a widespread but uncommon breeding species in arid river valleys of southern Alberta (Schowalter 1979).

This bat is a very rare visitor in Jasper and Banff National Parks. None were recorded during the present project. Banfield (1958) noted that only two specimens had been collected in Banff National Park and these were taken at the turn of the century. The National Museum of Canada holds one specimen of this species taken in Jasper National Park.

HABITAT

Occurring in Canada from the dry prairies of Alberta to rocky, forested, coastal British Columbia, this species is most commonly associated with rocky areas near forests.

LIFE HISTORY

This bat is thought to be migratory, moving south into the United States to hibernate in caves for the winter. In summer, they feed nocturnally and later at night than the little brown bat. The single young is born in July.

MANAGEMENT CONSIDERATIONS

This species presents no management problems at present because of its rarity and because it is a forest-dweller that rarely comes into contact with humans.

LONG-LEGGED BAT *Myotis volans* **LOBA**

STATUS AND DISTRIBUTION

The long-legged bat is limited in Canada to coastal and southern British Columbia and the mountains along the southern Alberta-British Columbia border. Smith (1979) described this bat as occurring in the mountain regions and along the Milk River in Alberta. Its range extends south through the United States to the Mexican border.

This species is very rare in Banff and Jasper National Parks. During this project, one animal was captured (20 August 1980) at a night roost in Jasper townsite. The animal was roosting under overhanging roof rafters on the outside wall of a house. Soper (1970) noted that only one specimen had been taken in Jasper National Park and felt that a few bats of this species wander east from British Columbia into the Alberta foothills. However locations such as Cadomin east of Jasper could also be the source of park bats. Schowalter (1979) captured 38 long-legged bats in one night at Cadomin Cave. Although this bat may occur in Banff National Park, no specimens have been collected.

HABITAT

The Jasper townsite was the only habitat identified in the present project. Banfield (1974) lists forest and open scrub as long-legged bat habitat. The species is probably limited in Banff and Jasper to the montane ecoregion.

LIFE HISTORY

This species probably migrates south from Canada to hibernate in warmer latitudes. It feeds nocturnally and its diet is insects.

MANAGEMENT CONSIDERATIONS

Nursery colonies may be found under the shingles of abandoned buildings. Assuming that the cold mountain climate or a restricted prey base does not limit the expansion of this bat in the mountain parks, allowing isolated buildings such as deserted cabins to stand would encourage this bat to establish breeding populations within the parks.

Rabies has been recorded in this species (Schowalter 1980).

SILVER-HAIRED BAT *Lasionycteris noctivagans* **SIBA**

STATUS AND DISTRIBUTION

The silver-haired bat occupies a broad band of territory across North America.In summer, the range reaches north to the Maritimes on the Atlantic coast, west to the Queen Charlotte Islands on the Pacific coast, south to a line joining Oregon and Pennsylvania. Winter range is south of Canada. In Alberta, this species appears around cities in late August and early September as it migrates south (Schowalter 1979).

This bat is rare in both Banff and Jasper National Parks. One specimen was found dead at the warden office near Jasper townsite during the present study (September 1977). A rabid specimen was collected in Banff in August 1973 (Schowalter, pers. comm.). The National Museum of Canada holds two specimens of this species from Jasper National Park and one from the Spray River in Banff National Park. None were trapped or detected ultrasonically during our surveys, however about ten were seen in late August 1980 feeding over the Smoky River at Grande Cache, north of Jasper (KVT).

HABITAT

Mountain habitats of the silver-haired bat cannot be described without more observations. Banfield (1974) describes foraging habitat as "rivers and lakes in the forests".

LIFE HISTORY

The silver-haired bat migrates south to hibernate in winter. Mating occurs in autumn before migration and the one or two young are born in June or July. These bats are solitary in summer. They are the first bats to emerge in the evening to begin foraging.

The major food source seems to be emerging aquatic insects.

MANAGEMENT CONSIDERATIONS

Nursery sites for this species have been found in crow's nests and in lumber piles as well as under tree bark. Potential nursery sites may occur in avalanche rubble and log piles along rivers.

Rabies has been recorded in this species (Schowalter 1980).

BIG BROWN BAT *Eptesicus fuscus* **BIBA**

STATUS AND DISTRIBUTION

The big brown bat occurs from Central America to southern Canada from British Columbia to New Brunswick. In Alberta, the range extends farther north and just reaches the Northwest Territories.

In Banff and Jasper National Parks, the big brown bat is generally uncommon. However, the big brown bat is the most common bat in both Banff townsite and Jasper townsite and is fairly common in the montane ecoregion. Soper (1970) may have underestimated numbers of this bat species when he termed it hypothetical in Jasper National Park or they have increased since then. In August 1980, big brown bats were found at Cottonwood Slough (3), Patricia Lake (5 seen, one male captured), Jasper townsite (20), over the lower Miette River (1-2) and at the Park horse corral (1) in Jasper National Park. A roost of at least 30 bats was found in the laundry room of the Jasper Park Lodge. Large numbers of bats seen along the Pyramid Bench suggest this area as a possible roosting site. This species was less common around the Banff townsite in August 1980. Only one was identified at the Vermilion Lakes. Banfield (1958) saw big brown bats frequently over Banff townsite and referred to two specimens collected at Johnston Canyon. Apparently, numbers of this species have declined around Banff townsite since the 1950's.

HABITAT

During this project, big brown bats were observed only in the montane ecoregion. Records of the Banff wardens indicate that this species was found in the Rimrock Inn. Habitats used by the big brown bat consist of the older buildings of the townsites, quiet ponds, lakes and rivers, and clearings in lodgepole pine forest. In the absence of man, this bat feeds over natural meadows and ponds and uses hollow trees in forests for roosts and nurseries. Street lights and warm attics are the townsite attractions for big brown bats.

LIFE HISTORY

The big brown bat shows greater tolerance to winter cold than other bats in Canada. It enters winter dormancy later and becomes active in spring earlier than other bats. Mating occurs in autumn. Spermatogenesis begins in late August and continues into late October. One-year-old females do not usually breed. Older females ovulate in early April. One to four ova implant but, in western populations, usually only one young survives. Young are born from early June to mid-July (Schowalter and Gunson 1979).

Owls are the main predators of this bat while flying; skunks and snakes may prey on grounded bats (Banfield 1974).

Insects preyed upon by big brown bats include the beetles, flying ants, flies, craneflies, stoneflies, mayflies, bugs, caddisflies, lacewing flies, scorpion flies and dragonflies (Phillips 1966).

MANAGEMENT CONSIDERATIONS

Rabies has been recorded in big brown bats (Schowalter 1980).

Although the big brown bat is clearly associated with the townsite area, no nurseries have been located and only one roost has been identified. Old buildings with accessible attics are being replaced by well-insulated and generally inaccessible attics. Thus, artificial nurseries, roosts and hibernation sites are disappearing. Natural sites used by these bats may need protection if the species is to remain in the mountain national parks.

HOARY BAT *Lasiurus cinereus* **HOBA**

STATUS AND DISTRIBUTION

The range of the hoary bat includes the United States, reaches northern South America and covers southern Canada. In the boreal forest, this species ranges as far north as Great Slave Lake, N.W.T. In Alberta, the hoary bat is uncommon and most specimens have been taken in the southern part of the province south of Edmonton (Schowalter 1979).

There are no records of the hoary bat in Jasper National Park. In Banff National Park, there are two records from May 1980 - one at the Banff golf course and one at the Forty Mile Creek Picnic Area. Three specimens were collected in Banff after the turn of the century (Banff Museum). The National Museum of Canada has one specimen collected along Stony Creek.

The hoary bat is rare in both parks and may not occur in Jasper National Park.

HABITAT

The hoary bat forages in open forests and over lakes. Roosts are usually conifers or the shade trees of villages.

LIFE HISTORY

The hoary bat is a solitary, tree-dwelling species. It hunts very late at night and is consequently not observed frequently. It winters in the southern United States, and is present in Canada from June to August. Mating probably occurs in August. Young are born in late June. There can be one to four young but two is the usual litter size. Sexes are segregated in spring and early summer.

Little is known about the particular insect prey of the hoary bat. It is suspected that the hoary bat may eat smaller bats.

MANAGEMENT CONSIDERATIONS

This species has been found to carry rabies (Schowalter 1980).

Even where they occur regularly, densities are not high. Living in forests, hoary bats should not need special protection in the parks.

AMERICAN PIKA *Ochotona princeps* **PIKA**

STATUS AND DISTRIBUTION

Pikas inhabit the mountains of western North America from northern New Mexico to British Columbia, Alberta, the Yukon Territory, the Northwest Territories and Alaska.

The pika is widely distributed and common in suitable habitat in Banff and Jasper. As many as 20 pikas have been observed at one location but one to four are usually observed at a time. Almost two and a half times more pikas were observed in this project than hoary marmots. Sites with ten or more pikas were found in the Baker Creek, middle and upper Bow River, Bryant Creek, Clearwater River and Mistaya River watersheds. In the middle Bow River, Bryant Creek, Clearwater River, Pipestone River and Sunwapta River watersheds, pikas were observed at 15 or more locations. Low numbers of pikas were found in the lower Athabasca River, Blue Creek, lower Bow River, upper Cascade River and lower Spray River valleys.

HABITAT

Pikas occur from the lower subalpine to the alpine. In six out of nine alpine ecosites, use by pikas was ranked high. Rarity in the montane is probably related to a lack of rock piles. There is one record from Vermilion Lakes. Pikas are found at elevations as high as vegetation occurs and as low as rock slides penetrate the subalpine forest.

LIFE HISTORY

Pikas are diurnal. Although they are visible from May to October (4 May to 9 October in this project), they remain active after disappearing under the snow. Two records of pika tracks in snow (both on 25 January 1979) and one record of an animal calling (9 February 1980) suggest that pikas spend very little time on top of the snow in winter. Food in stored in "hay piles" for winter use. Harvest and storage of food plants begins in late summer and continues until frost kills the plants. Pika nests are hidden deep in rock crevices. Mature females can have two litters of two to four young each between May and August (Millar 1974). Birth of the first litter of the summer coincides with the initiation of plant growth (Millar 1972). Markham and Whicker (1973) recorded a mean litter size of 3.2 in Colorado based on embryo counts on 53 females. Pikas mature as yearlings. Few live longer than five years in Alberta (Millar and Zwickel 1972).

Short-tailed weasels prey on pikas by pursuing them through their tunnels. Avian predators include the golden eagle and the large buteo hawks. While foraging away from the protective cover of the talus slope, pikas may fall prey to marten, wolverines, lynx, bears, foxes and fishers.

Pikas use a wide variety of food plants. The main part of the diet is made up of grasses and sedges. This is supplemented by a variety of flowering plants and the tender shoots of woody shrubs.

MANAGEMENT CONSIDERATIONS

Because of the nature of their habitat, pikas are not usually threatened by human activities. In some areas, horses may compete for food resources.

VARYING HARE *Lepus americanus* **VAHA**

STATUS AND DISTRIBUTION

The varying hare is found throughout Canada south of the treeline and in northern United States.

This species is widespread and common in Jasper and Banff National Parks. Fluctuations in numbers occur over periods of 6 to 13 years and, in northern Canada, densities can range from 0.4 to 1300 hares per square km. When a peak population was reported on the Alberta prairies in the 1950's, Banfield (1958) reported that he did not observe hares to be uniformly abundant throughout Banff National Park. Soper (1970) provides some suggestion that numbers of hares in Jasper National Park undergo fluctuations by recalling reports by Jasper area residents of "astonishing numbers" of hares from 1912 to 1914 and by relating his impression of hare numbers as being "scarce, sometimes remarkably so". During the present project's winter tracking, an average of 0.8 tracks/10km-day (N=6) was found in 1975, 15 in 1976 (N=2), 3.4 in 1977 (N=22), 2.6 in 1978 (N=179), 1.8 in 1979 (N=142), 4.0 in 1980 (N=365) and 2.3 in 1981 (N=31). While the highest number occurs in 1980 coinciding with peak numbers of hares on the Alberta prairie, the average number of tracks per transect shows no clear pattern of a build-up towards a 1980 peak.

HABITAT

Snowshoe hares may be found from the montane to the lower edge of the alpine ecoregion but hares are most abundant at lower altitudes. Nineteen montane ecosites had an average of 5340 pellets per hectare, 47 lower subalpine ecosites had 4230 pellets per hectare, 30 upper subalpine ecosites had 3550 pellets/hectare and 3 alpine ecosites that had hare pellets had 20/hectare. Adequate forest cover is a major factor limiting Varying hare occurence. Of the 26 vegetation types receiving high use by hares, only seven were not closed forests (Figure 3.30). The highest hare pellet concentrations (22092/ha) occur in lodgepole pine/dwarf bilberry (C9) forest. Also strongly favored by hares are white spruce/buffaloberry/fern moss (C26) forest (18800 pellets/ha), white spruce/prickly rose/horsetail (C4) forest (18533 pellets/ha), black spruce-lodgepole pine forest (17467 pellets/ha) and white spruce-Douglas fir/feathermoss (C5) forest (15800 pellets/ha). Forest types which receive low use are aspen, balsam poplar, subalpine larch and Engelmann spruce-subalpine fir forests (120 to 520 pellets/ha).

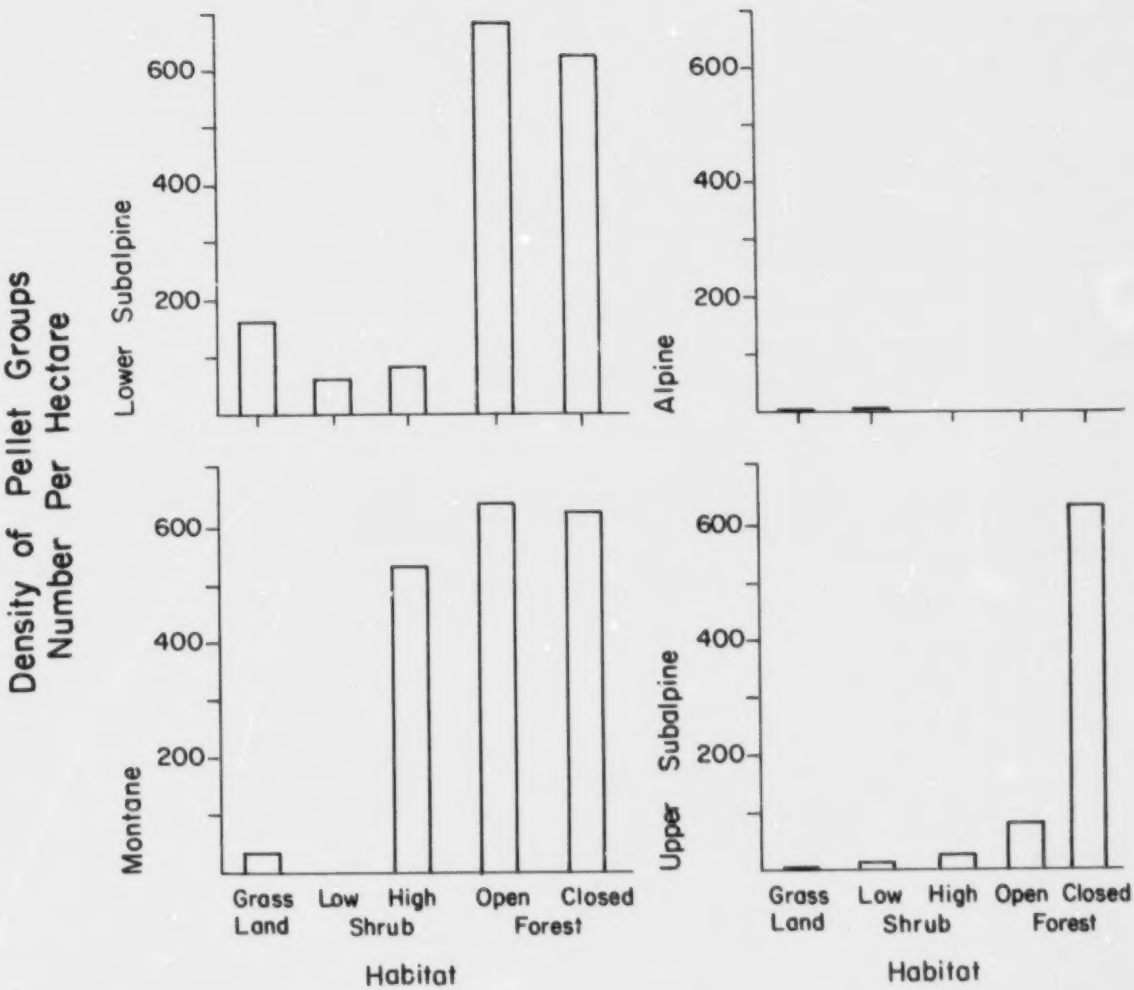
LIFE HISTORY

Hares are crepuscular and nocturnal, and are active all winter. Breeding begins in mid-March and continues to September. Mean litter size is four with a range of one to eight. A mature female may have up to four litters per year but the average is 2.75 litters. Young-of-the-year hares do not breed. No litter size data were collected during this inventory.

In summer, food consists of a wide variety of green grasses and forbs and the leaves of soft deciduous trees and shrubs. Winter foods include buds, twigs, bark and evergreen leaves of woody plants. Conifer needles and buds are important winter foods because of their palatability and availability (Wolff 1978).

A great horned owl was observed feeding on a Varying hare (19 January 1980). Other predators of the hare include the great grey owl, barred owl, broad-winged hawk, red-tailed hawk, Cooper's hawk, goshawk, lynx, red fox, coyote, wolf, mink, fisher and

Figure 3.30. Habitat use by varying hare, based on pellet counts.



marten.

MANAGEMENT CONSIDERATIONS

Numbers of Varying hare typically fluctuate and it is consequently difficult to establish optimum population sizes. Hares are an important food source for carnivores, particularly in winter when other small mammals are under the cover of snow. If maintaining a food source for carnivores is a priority and a problem, habitat manipulation to favor hares may be considered. This could be done by maintaining a young, shrubby forest through controlled burning of alluvial forests. Forested bogs are important hare habitat that should not be disturbed.

WHITE-TAILED JACK RABBIT *Lepus townsendii*

STATUS AND DISTRIBUTION

A white-tailed jack rabbit was collected at Indianhead in 1892 by the Geological Survey of Canada. The capture location was along the eastern boundary of Banff National Park. This specimen was recorded by the Banff Museum. There are no known records since that time. Given that this species is native to prairie habitats, it is not likely to reoccur in Banff or Jasper National Parks.

LEAST CHIPMUNK *Eutamias minimus* **LECH**

STATUS AND DISTRIBUTION

The Least chipmunk is found from the southern Yukon Territory east to northern Ontario. Its range reaches south from central Alberta along the Rocky Mountains and from southern Saskatchewan and Manitoba into North Dakota and Minnesota.

The Least chipmunk is common in suitable habitat in Jasper and Banff National Parks. Although this species has been found in all the watersheds of the two parks, it is generally absent from portions of Banff National Park frequented by the Yellow pine chipmunk (*E. amoenus*) (Figure 3.31, 3.32). Meredith (1975, 1977) examined the basis for the geographic separation of these two chipmunk species and the distribution of the least and yellow pine chipmunks: "North of the Bow River the Least chipmunk occupies the boreal forests and the eastern Front Ranges of the Rocky Mountains, while the Yellow pine chipmunk occupies the forests along the Continental Divide. These populations are not altitudinally ecoregiond but are generally separated by geography, high alpine ridges and peaks forming much of their boundary. South of the Bow River the species are altitudinally ecoregiond, the Least chipmunk occupying islands of alpine and timberline areas in a sea of forest occupied by the Yellow pine chipmunk". Observations during the present project are consistent with this description of the least chipmunk in Banff National Park. The few exceptions occur along the Bow River and may be related to dispersal facilitated by bridges, natural (ice) or man-made. In Jasper National Park, the least chipmunk has been generally found throughout the park. Soper (1970) referred to the distribution of the least chipmunk in Jasper as "very extensive and fairly consistent". It appears that in parts of Jasper where the yellow pine chipmunk has been recorded, it does not occur in such numbers as to cause the exclusion of the least chipmunk (e.g. lower and upper Athabasca River watersheds).

In ecosites where least chipmunks were snap trapped, they occurred at a rate of 0.19 animals per 100 trap nights. This compares with a capture rate of 0.12 yellow chipmunks per 100 trap nights or 3.06 deer mice per 100 trap nights in ecosites where

Figure 3.31. Distribution of chipmunks observations in Banff.

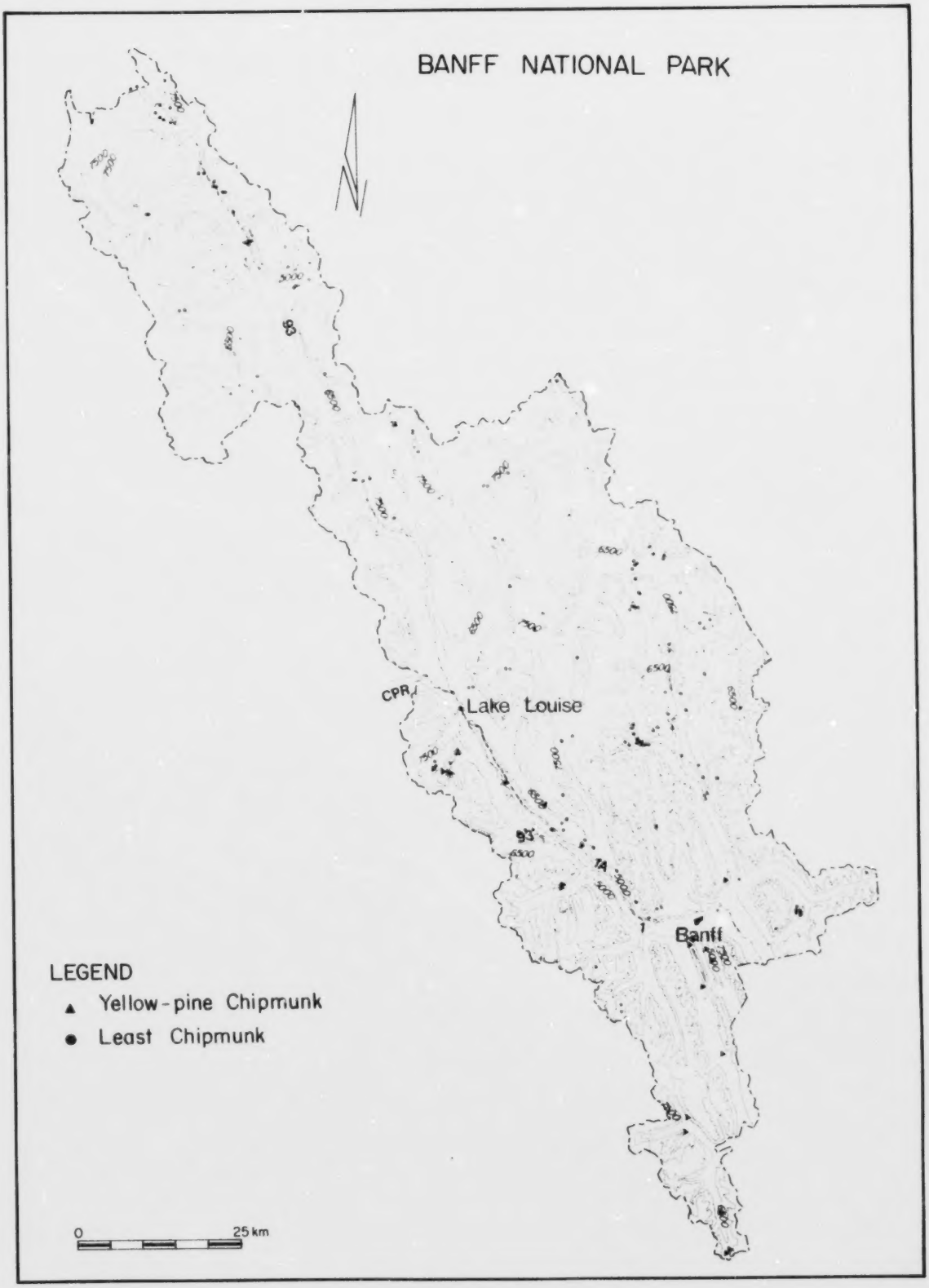
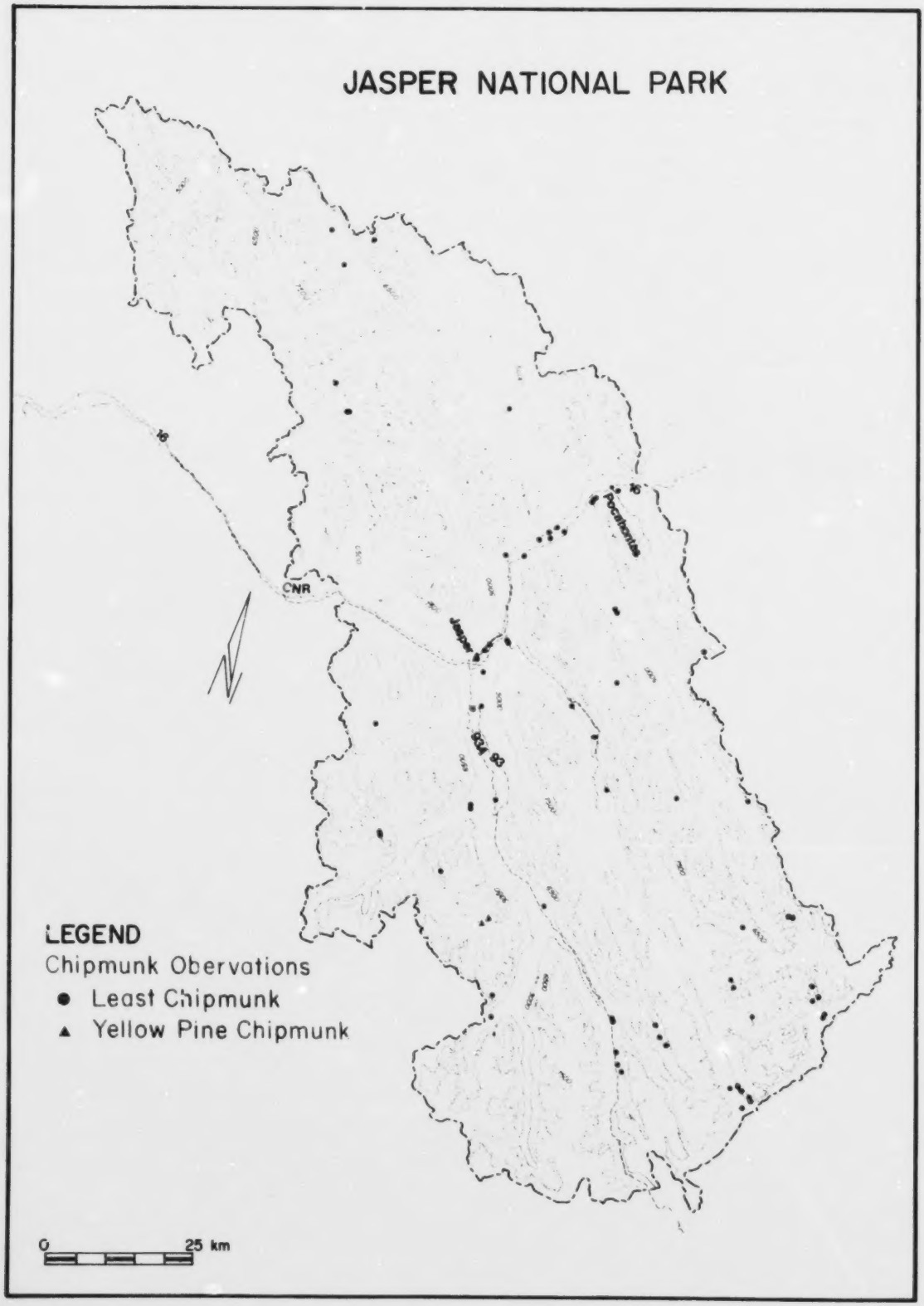


Figure 3.32. Distribution of chipmunks observations in Jasper.



they occurred. There were 113 least chipmunks captured in all snap trap sampling (3% of total catch),compared to 60 yellow pine chipmunks and 1647 deer mice.

HABITAT

Least chipmunks occur from the montane to the alpine and are most common in the upper subalpine. The average catch per 100 trap nights (in ecosites where least chipmunks were trapped) was 0.59 in the upper subalpine, 0.55 in the lower subalpine, 0.43 in the montane and 0.29 in the alpine. This chipmunk is commonest on south and southwest-facing slopes in open forests. Tree cover appears to be variable but ground cover often includes bearberry and shrubby cinquefoil. This ground cover and the open nature of forests where this species occurs suggests the importance of warmth and dryness in chipmunk habitat. On mountain slopes where the least and the yellow pine chipmunks are found, the yellow pine chipmunk tends to occur in forests with denser cover and at lower altitudes than the least chipmunk. A catch per 100 trap nights of 0.561 to 2.170 was considered high, 0.266 to 0.560 medium and 0.001 to 0.265 low.

LIFE HISTORY

The least chipmunk is strictly diurnal. In winter, this species hibernates in a nest at the end of an underground tunnel, arousing a few times to feed on stored food. (During this project, Least chipmunks were seen above ground from April 26 to October 23). The summer nest may be in a woodpecker nest cavity, in a hollow log or in a nest constructed from grass and leaves in the branches of a tree. Breeding begins two weeks after the females emerge from hibernation (Criddle 1943). Litters are born from mid-May to late June. In Alberta, a female chipmunk bears one litter per year with a mean litter size of 3.9 young (1 litter with 3 embryos; 6 litters with an average of 4.0 placental scars, S.D.=1.26) (mean of 5.46 (Criddle 1943), 4.19 (Sheppard 1969)).

During this project, only the sharp-shinned hawk was observed to prey on the least chipmunk. Chipmunks, however, have a large number of predators including many hawks and mammalian carnivores from the short-tailed weasel to the grizzly bear.

Chipmunks eat seeds, nuts, berries, invertebrates (mainly insects) and occasionally young birds or bird's eggs. Only the seed of fruit is eaten, not the flesh of the fruit. The least chipmunk was twice observed eating bearberries.

MANAGEMENT CONSIDERATIONS

The least chipmunk is an important prey species for hawks and mammalian carnivores.

The segregation of territory occupied by this chipmunk and the yellow pine chipmunk is of scientific interest. Records of observations of the two chipmunk species should be mapped continuously to monitor changes in distribution which may occur and any specimens which become available should be submitted to a museum for identification to species and subspecies.

YELLOW PINE CHIPMUNK *Eutamias amoenus* YECH

STATUS AND DISTRIBUTION

Yellow pine chipmunks occur in the Rocky Mountains from northern California to central British Columbia.

In Banff National Park, the yellow pine chipmunk is restricted to the area west of the Bow River and south of Kicking Horse Pass. Within this area the yellow pine chipmunk is common (Figure 3.31, 3.32). The status of this chipmunk in Jasper National Park is unclear. While there were four sightings of yellow pine chipmunks in Jasper (two in the lower Athabasca River and two in the upper Athabasca River watersheds), there were no specimens taken in snap traps. Soper (1970) noted specimens collected at various locations in Jasper, described it as "... by no means abundant or evenly distributed... " and suggested that "... this chipmunk was more plentiful half a century ago". The northwest corner of Jasper was not sampled heavily by trapping, and the yellow pine chipmunk may occur along the western boundary of Jasper National Park in the Smoky River watershed.

The yellow pine chipmunk occurred at lower densities than the least chipmunk in their respective ranges. The least chipmunk was captured at a rate of 0.19 animals per 100 trap nights and the yellow pine chipmunks was captured at a rate of 0.12 animals per 100 trap nights in ecosites where chipmunks were captured. There were 60 yellow pine chipmunks taken in all snap trapping, constituting 2% of total catch.

HABITAT

The yellow pine chipmunk was trapped in one montane ecosite (1 individual) 10 lower subalpine ecosites (55 individuals) and in three upper subalpine ecosites (4 individuals). The highest elevation at which this species was trapped was 2380 m. Vegetation supporting high numbers of Yellow pine chipmunks include open and closed Engelmann spruce-subalpine fir forests having diverse herb and shrub layers, usually on till or colluvium slopes of variable orientation and steepness. Negus and Findley (1959) in Wyoming found this mammal to be most abundant in open lodgepole pine and aspen forests with shrubby of herbaceous understories. In this project, a catch per 100 trap nights of 1.00 to 2.77 is considered high, 0.312 to 0.999 medium, and 0.00 to 0.311 low.

LIFE HISTORY

The yellow pine chipmunk lives a solitary life except during the breeding season. It is diurnal, with activity peaks in early morning and evening. As little body fat is accumulated for winter energy, food must be stored and this is eaten during short interruptions of hibernation. Mating occurs in early spring and the young are born between mid-May and early June. Litter size averages 3.8 young in Banff and Jasper (S.D.=1.4, N=11, based on counts of embryos and placental scars) and 4.6 in Sheppard (1969). About two thirds of the chipmunks breed as yearlings but this proportion varies from year to year.

Foods of this chipmunk include seeds, fruit, insects, fungi and corms and are similar to those of the least chipmunk (Sheppard 1971).

Predators include the pygmy owl, goshawk, Cooper's hawk, weasels, coyotes and badgers.

MANAGEMENT CONSIDERATIONS

Comments concerning the least chipmunk are also applicable to this species.

HOARY MARMOT *Marmota caligata* **HOMA**

STATUS AND DISTRIBUTION

The range of the Hoary marmot includes mountains of the northern Cordilleran region in Montana, British Columbia, western Alberta, Yukon Territory and Alaska.

This species is common in suitable habitat and is widely distributed throughout Banff and Jasper National Parks. Some watersheds such as the lower Athabasca River, Blue Creek, Spray River, Rocky River, Pipestone River, Nigel Creek, and upper North Saskatchewan River and the Jasper townsite and Banff townsite areas produced no records of marmots during this inventory. This may be due to a lack of habitat or be an artifact of observers having spent little time in the alpine and upper subalpine parts of these areas. In the middle Athabasca, middle Bow, Cairn, upper Rocky and middle Snake Indian watersheds, marmots were observed at ten or more locations. As many as eight marmots were seen at one location in the lower Maligne valley and the Snaring valley but usually only one to three are seen at any location. Hoary marmots were reported less commonly than golden-mantled ground squirrels or pikas. There were 21% more observations of golden-mantled ground squirrels than hoary marmots and there were over two and one-third times as many pika observations as marmot observations. Hoary marmots are less ubiquitous than these species but can be locally common.

HABITAT

Hoary marmots occur from the lower subalpine up to the limit of vegetation growth in the alpine. Ecosites which were ranked high in use by marmots were in the alpine and upper subalpine and were characterized by till and colluvium. Marmots were found in open Engelmann spruce-subalpine fir forests in the upper subalpine, in upper subalpine thickets and in alpine heath and tundra vegetation.

LIFE HISTORY

Hoary marmots live in loose colonies. Their whistling upon the approach of predators is a communal defense mechanism. Dens are located under the edges of rock slides, in loose talus or under large boulders in open, hilly ground where some predator defense is afforded by the rock. During their eight months of hibernation, marmots live on stored fat. Marmots were observed during this project from June 6 to September 18. Mating is thought to occur upon emergence from hibernation in spring. Litters of four or five young are born in late May or early June.

Vetches, sedges, fleabanes and fescues made up 80% of the diet of an Alaskan marmot population (Hansen 1975). Lichens, mosses, mountain avens and willows constituted an additional 10% of the diet. The same or closely related plant species are available to marmots in the Alberta Rockies.

Black bears, grizzly bears, wolves and golden eagles are the main predators of hoary marmots.

MANAGEMENT CONSIDERATIONS

Trails through marmot habitat could lead to reduced marmot numbers and reduced potential for such marmot predators as the golden eagle, due to trampling of vegetation, stress from frequent disturbance, and losses of juveniles to uncontrolled dogs.

COLUMBIAN GROUND SQUIRREL *Spermophilus columbianus* COSQ

STATUS AND DISTRIBUTION

The Columbian ground squirrel occurs in the central Rocky Mountains from central British Columbia and western Alberta to northern Nevada.

This ground squirrel is abundant and widespread in favorable habitat in both Banff and Jasper National Parks. Watersheds in which this species had not been recorded include the Cairn River, Fiddle River, Medicine-tent River, Mistaya River, upper and lower Snake Indian River, Southesk River, Moosehorn Creek and Sulphur River. The reason for this may simply be that the common species tend not to be written into notes with the same regularity as rarer species, or the lack of a sampling method appropriate for this species. Numbers of observations of the Columbian ground squirrel significantly exceed those of the golden-mantled ground squirrel. The number of golden-mantled ground squirrels reported during this project was only 16% of the number of Columbian ground squirrels recorded. The Columbian ground squirrel appears numerous even when compared to the abundant red squirrel. Both species were recorded on call-count transects. The red squirrel occurred in 90 ecosites and had an average density index of 18.34 for those ecosites. The Columbian ground squirrel occurred in 21 ecosites and had an average density index of 5.86. Since Columbian ground squirrels are not normally active at dawn when the transects are conducted, this is an underestimation of Columbian ground squirrel density.

Banfield (1958) described this ground squirrel in Banff National Park as "one of the commonest and most widespread mammals in the park" and Soper (1970) commented that "they abound in large colonies, or in lesser groups and scattered pairs" in Jasper National Park. While colonies may have up to 50 animals, most colonies appear to have 10 or 20 animals. These counts are conservative, however, because they are based on the number of animals visible above ground at one time. Colonies of 50 animals were found in the alpine in the Baker Creek and upper Bow River watersheds and in the upper subalpine in the middle Bow and upper Spray River watersheds.

HABITAT

Columbian ground squirrels occur from the montane (985 m) to the alpine (2400 m). Among the ecosites ranked high in use by this species, three are montane, six are lower subalpine, fourteen are upper subalpine and five are alpine. Landforms receiving the highest use are till, fluvial and colluvial in origin and are covered with grassland, shrubby grassland or heath. Aspect and steepness of slope is variable and moisture conditions range from subxeric to subhygric.

LIFE HISTORY

Columbian ground squirrels are colonial. Their diurnal, above-ground activity levels appear to be strongly correlated with intensity of subshine (Shaw 1945). In summer, extensive tunnel systems are dug. Columbian ground squirrels dig winter hibernation dens off the summer tunnels. Given that September 26 was the latest date that this ground squirrel was observed above ground and April 11 was the earliest date, six to seven months must be spent in hibernation. Adult males appear first in spring followed by the adult females and then the young of the previous year. Mating occurs soon after the females emerge from hibernation. Litters average four young but range from two to seven. Young are born from early May at lower elevations to late June at higher elevations. Hibernation also begins earlier at lower elevations than higher ones.

Ground squirrels are an important source of food for several predators. During this project, coyotes were observed hunting in ground squirrel colonies and one coyote was seen to kill a squirrel. Diggings of grizzly bears were observed in ground squirrel colonies. Other predators include weasels, golden eagles, large buteo hawks such as the

red-tailed hawk, badgers, foxes and cougars.

Foods of this species are wide and varied and include the seeds of grasses sedges and forbs and the roots, stems, leaves, bulbs and flowers of many plants.

MANAGEMENT CONSIDERATIONS

At low elevations, the Columbian ground squirrel must compete with human activities for habitat. Parking lots, roads, picnic areas, camping areas and other visitor services occupy the habitats favored by ground squirrels in the montane and lower subalpine. However, developments in closed forests can also create new habitat for this species. The frequent presence of visitors in ground squirrel habitat interferes with the activity of predators. Young ground squirrels are commonly killed on roads and scavengers feeding on the carcasses are subsequently killed.

Because the Columbian ground squirrel is diurnal and is frequently encountered by park visitors, it lends itself well to interpretation to visitors.

GOLDEN-MANTLED GROUND SQUIRREL *Spermophilus lateralis* **GOSQ**

STATUS AND DISTRIBUTION

The Golden-mantled ground squirrel occurs in the Rocky Mountains of British Columbia and Alberta, south to Arizona.

While widespread and common throughout most of Jasper and Banff National Parks, this ground squirrel is virtually absent from the montane ecoregion, with very few observations of this species in the two townsite areas, in the lower Athabasca valley and in the lower Bow valley. In Jasper National Park, Soper (1970) also found this ground squirrel "... widely distributed in the cordillera [but] scarce or non-existent ... at lower levels. During this project, there were only five observations of golden-mantled ground squirrels in the montane (all in the lower Bow valley) out of a total of 381. With a total of 2448 observations of the Columbian ground squirrel in both parks, the Columbian ground squirrel is almost six and a half times more observable than the golden-mantled ground squirrel. The hoary marmot was recorded fewer times (316 observations) and the pika twice as often (752 observations) as the Golden-mantled ground squirrel.

HABITAT

The Golden-mantled ground squirrel occurs commonly from the lower subalpine to the alpine but only rarely in the montane. Among the 20 ecosites having the most records of this species nine are lower subalpine, four are upper subalpine and seven are alpine. These ecosites are characterized by till and colluvial material, variable aspect and steepness of slopes, and relatively dry, open forest cover. Vegetation types preferred by this ground squirrel are diverse. It is found in open forests of Engelman spruce and subalpine fir with heath understory; open forests of lodgepole pine, Douglas-fir and Engelmann spruce with a diverse herb layer; shrub thickets of dwarf birch, willow and shrubby cinquefoil; alpine heath tundra; rocky, herb mats dominated by yellow mountain avens; and alpine tundra dominated by mountain avens.

LIFE HISTORY

This diurnal rodent is more active in warm, sunny weather than under cloudy, wet conditions. In winter it hibernates, living on stored fat and food caches. In Banff and Jasper it has been observed from 23 May to 26 September. Mating is in spring after the females emerge from hibernation. The single annual litter consists usually of four to six young.

Food sources are diverse: seeds, fungi, leaves, flowers, fruit and roots and some insects.

Predators of the golden-mantled ground squirrel in the mountain parks include goshawks, red-tailed hawks, red foxes, coyotes, weasels and grizzly bears.

MANAGEMENT CONSIDERATIONS

Habitats used by golden-mantled ground squirrels are not concentrated in valley bottoms and therefore are not often taken for development of visitor services. Only the hiker who begins to climb the mountain slopes will encounter this species. Commonly encountered along trails by park visitors and often confused with the chipmunk, this species is of interpretive interest.

The golden-mantled ground squirrel can harbor the Rocky Mountain spotted fever tick (Banfield 1974).

RED SQUIRREL *Tamiasciurus hudsonicus* **RESQ**

STATUS AND DISTRIBUTION

Red squirrels occur in forested North America from the treeline in the north to the northern United States. The range almost extends to the Mexican-American border along the Rocky Mountains and includes the New England states. Excluded from its range are the island of Newfoundland and the prairie region.

Red squirrels are widely distributed in the forested regions of Banff and Jasper National Parks. Densities vary annually and between forest types but this species is very common in park forests. Red squirrels and Columbian ground squirrels were recorded on Emmlen call-count transects and a density index was calculated for each species on each ecosite and in each vegetation type. The density index for the red squirrel was 18.34 when indices for the 90 ecosites in which it occurred were averaged. The average of 21 ecosite indices for the Columbian ground squirrel was 5.86 or only a third that of the red squirrel.

HABITAT

Red squirrels are found from the montane to the upper subalpine. They occur in highest numbers in the montane ecoregion and lower subalpine. Thirty-three ecosites support high densities of red squirrels and 18 of these ecosites are montane, 14 are lower subalpine and only one is upper subalpine. Highest Red squirrel density indices are 39.0 in Douglas-fir forest (C1), 37.0 in poplar forests (C16, C28), 36.5 in white spruce forests (C2, C4, C26, C27), 23.8 in lodgepole pine forests (C3, C6, C9, C10, C11, C18, C19, C20, C29) and 12.0 in Engelmann spruce-subalpine fir forests (C13, C14, C15, C21, C30). Open forests have lower densities of squirrels than closed forests and the lower densities in Engelmann spruce-subalpine fir forests as compared to other forest types is evident in both closed and open forests. There were density indices of 29.8 in Douglas-fir open forest (O5), 21.1 in white spruce open forest (O3, O17), 18.9 in stunted aspen woodland (O1) and 7.43 in Engelmann spruce-subalpine fir open forest (O8, O9, O10, O12, O14). A density index of 66.3 was recorded in limber pine open forest. A density index of 22.0 to 78.9 is considered high, 10.0 to 21.9 medium and 0.1 to 9.9 low.

LIFE HISTORY

Red squirrels are diurnal. In winter, they do not hibernate but they do become inactive in burrows or nests during storms and cold weather. In late summer and early

autumn, squirrels spend most of their active time storing conifer cones in damp earth or in chambers under logs and stumps. This stored food is consumed during the winter. By spring, refuse heaps or middens of conifer cone scales have been deposited on the ground above the winter food caches. Because the same food cache and midden can be used winter after winter, the size of the midden is an index to habitat quality for the red squirrel. Red squirrels lead solitary existences and, even in the breeding season, only a weak association exists between mates. Dens are shared with mates and young but red squirrels are intolerant of other red squirrels, other squirrel species, small mammals and birds. In northern and western parts of their range, they usually have one litter per year. Second litters have been recorded in British Columbia, eastern North America and southern parts of the range (Millar 1970). In Alberta, young leave the nest in late July and August. Litter sizes range from one to eight young with means of 3.3 (Dolbeer 1973) and 3.9 (Kemp and Keith 1970).

Red squirrels are preyed on by a number of mammalian and avian predators. In the mountains, squirrels may fall victim to the red-tailed hawk, Cooper's hawk, goshawk, barred owl, great horned owl, marten, fisher, lynx, long-tailed weasel, coyote, wolverine and wolf. Although it is not a major prey species for any one predatory species, its abundance and ubiquity help offset periods of scarcity of other prey species.

This species' varied diet includes conifer cones, buds, flowers, fleshy fruit, bark, mushrooms, sap, insects, birds' eggs and fledglings, and mice. Fluctuations in red squirrel numbers have been related to fluctuations in the annual cone crop of the white spruce (Kemp and Keith 1970).

MANAGEMENT CONSIDERATIONS

As a prey species, red squirrels are important to a number of avian and mammalian predators. Squirrel populations should be secure from human interference because of the extent of their habitat.

This noisy rodent and its middens are familiar to many park visitors and are therefore of interpretive interest.

NORTHERN FLYING SQUIRREL *Glaucomys sabrinus* **FLSQ**

STATUS AND DISTRIBUTION

The Northern flying squirrel ranges north to a line between Labrador and Alaska. It does not occur on the island of Newfoundland or the prairies in Canada. The southern limit of its range is the northern United States in the Appalachians and the Rockies.

The northern flying squirrel is uncommon but widely distributed in both Banff and Jasper National Parks. Densities of this species are difficult to assess because the animals are nocturnal and are generally not vulnerable to the snap trap. Fifteen observations of the flying squirrel were recorded in Banff and five were recorded in Jasper. Flying squirrels were observed in the following watersheds: lower Bow valley (one sighting, one trapped specimen, and four dead Northern flying squirrels in an owl nest), middle Bow valley (two trapped specimens and one track), upper Bow valley (two tracks), lower Brazeau valley (two trapped specimens), northern Brazeau valley (two tracks), Clearwater valley (one track), Johnston Creek (one track), Miette River (one trapped specimen), Mistaya valley (two trapped specimens), Siffleur (one trapped specimen) and the lower Spray River (two trapped specimens). Banfield (1958) described this species as "... probably generally distributed throughout Banff Park... " and Soper (1970) commented that the flying squirrel "... can be fairly common in some favourable tracts of forests". These comments are consistent with the data available from the present project. Additional specimens from the Alexandra River, lower Athabasca valley, middle Bow valley, lower

Maligne valley and Snaring River watersheds were taken for the National Museum of Canada or the University of Alberta Zoology Museum.

HABITAT

All records from the present project show that the flying squirrel occurs only in the montane (4 observations) and lower subalpine (15 observations). Northern flying squirrels prefer mature closed forest on glacial till or alluvial areas. Nine records were in Engelmann spruce-subalpine fir forest, 8 in lodgepole pine-spruce or lodgepole pine forests, and one each in closed aspen forest and Douglas fir/hairy wild rye (C1) forests.

LIFE HISTORY

Unlike the red squirrel, this squirrel is social. Adults commonly associate, even during feeding. In winter, as many as 20 may share a communal den in a tree cavity. Nests constructed from bark and twigs and located in tree branches are used in summer, whereas nests in woodpecker nest cavities are used in winter (Cowan 1936). In summer, males occupy nests separate from the adult females and their young. Mating occurs in late March to early April. The single annual litter is born in late May or early June. An average of three young are born in each litter.

Foods of flying squirrels include the birds, leaves, seeds, fleshy fruits and nuts of many trees and shrubs, arboreal lichens, fungi, insects, birds and birds' eggs. Flying squirrels also scavenge on carcasses.

Diurnal predators generally do not prey on flying squirrels. Owls, hawks active at dawn and dusk, and mustelids such as marten and fisher prey on this squirrel. The domestic cat also takes squirrels. A Great Horned Owl nest on Mount Cory in the lower Bow River valley contained 4 dead Northern flying squirrels in May 1978.

MANAGEMENT CONSIDERATIONS

Old hollow trees are often used for nesting sites. These trees also tend to be cut for firewood or cut down simply because they are dead and unstable.

Flying squirrels may be killed by power lines and by domestic cats left outside at night.

NORTHERN POCKET GOPHER *Thomomys talpoides* **hypothetical**

STATUS AND DISTRIBUTION

Northern pocker gophers occur commonly across the Prairie Provinces of Canada from southwestern Manitoba to the foothills of the Rockies in southern Alberta. They also occur in the mountain valleys of south-central British Columbia.

Evidence of the northern pocket gopher in Banff National Park exists in the form of push ups or earth mounds found in the Ghost Lakes area on 29 August 1978. Similar sign, although possibly related to water vole (*Arvicola richardsoni*) activity, were found in the Healy Pass and Palliser cabin areas. This species must be regarded as hypothetical in Banff National Park and absent from Jasper National Park. Museum records and the literature provide no records of the pocket gopher in either park. Wilson (1969) noted sign of this species outside Banff as far west as Morley, at the point where highway 1A crosses the Ghost River and "quite far up the Sheep River valley".

HABITAT

In Banff National Park, the pocket gopher may occur from the montane to the upper subalpine. Negus and Findley (1959) found pocket gophers in Wyoming in sage, forb-grass meadows, hay fields, aspen groves, subalpine and alpine meadows and forest clearings. Soils are usually deep, heavy and moist but never flooded.

LIFE HISTORY

Pocket gophers are solitary outside of the mating season. Concentrations of animals in good habitat suggest a colonial existence. They are active all year in underground burrows. In spring, however, pocket gophers may burrow above the soil through snow to reach food sources. The single annual mating period occurs in April and early May and young are born in late May to early June. Litter size ranges from one to eight young.

Preying on a pocket gopher usually involves digging. However, pocket gophers may venture out of their tunnels at night and become easy prey for Great Horned Owls, Great Gray Owls, and Long-eared Owls. Other predators include weasels, coyotes, foxes and badgers.

Most of the pocket gopher's diet is comprised of the roots of perennial forbs. The summer diet also includes grasses and green leaves and stems of other plants.

MANAGEMENT CONSIDERATIONS

If this species does occur within park boundaries, it must only be present in extremely low numbers. Because of such low numbers and because of general persecution in prairie agricultural lands, any habitat occupied by the pocket gopher should be protected.

AMERICAN BEAVER *Castor canadensis* **BEAV**

STATUS AND DISTRIBUTION

Beavers occur from the northern treeline in Alaska and northern Canada south to the Mexican-American border. Densities are low in the prairie region.

The fur trade of the mid-nineteenth century focussed on the beaver and led to its depletion throughout northern Canada and the valleys of the Rockies. Beavers were virtually gone from the Bow valley in 1909 (Green 1944). Loring considered them rare in the Jasper area in 1895 (Soper 1970). Within twenty years, however, beavers had increased and spread into many parts of Jasper (Hollister 1912, Anderson 1918).

The numerous fires of the late 1800's, and the period during which beavers were rare, led to the creation of ideal habitat in the form of young aspen forest and willow thickets. A population boom evidently took place until the 1930's (Anderson 1938, Green 1944) when beavers occupied almost every accessible watercourse and pond in both parks.

By 1941 the Banff Advisory Council was complaining to the park administration that beavers were too numerous. A mosquito-control program led to the destruction of 235 beaver dams in the lower Bow valley between April and August 1943.

A gradual decline took place in the late 1940's and 1950's (Ferris 1956) as the most productive aspen and willow stands were depleted. Beaver populations were not monitored in either park from the 1930's until the present but Soper (1970) presented evidence that overpopulation had led to the abandonment of many former beaver areas in Jasper.

Figure 3.33. Distribution of beaver and muskrat observations in Banff.

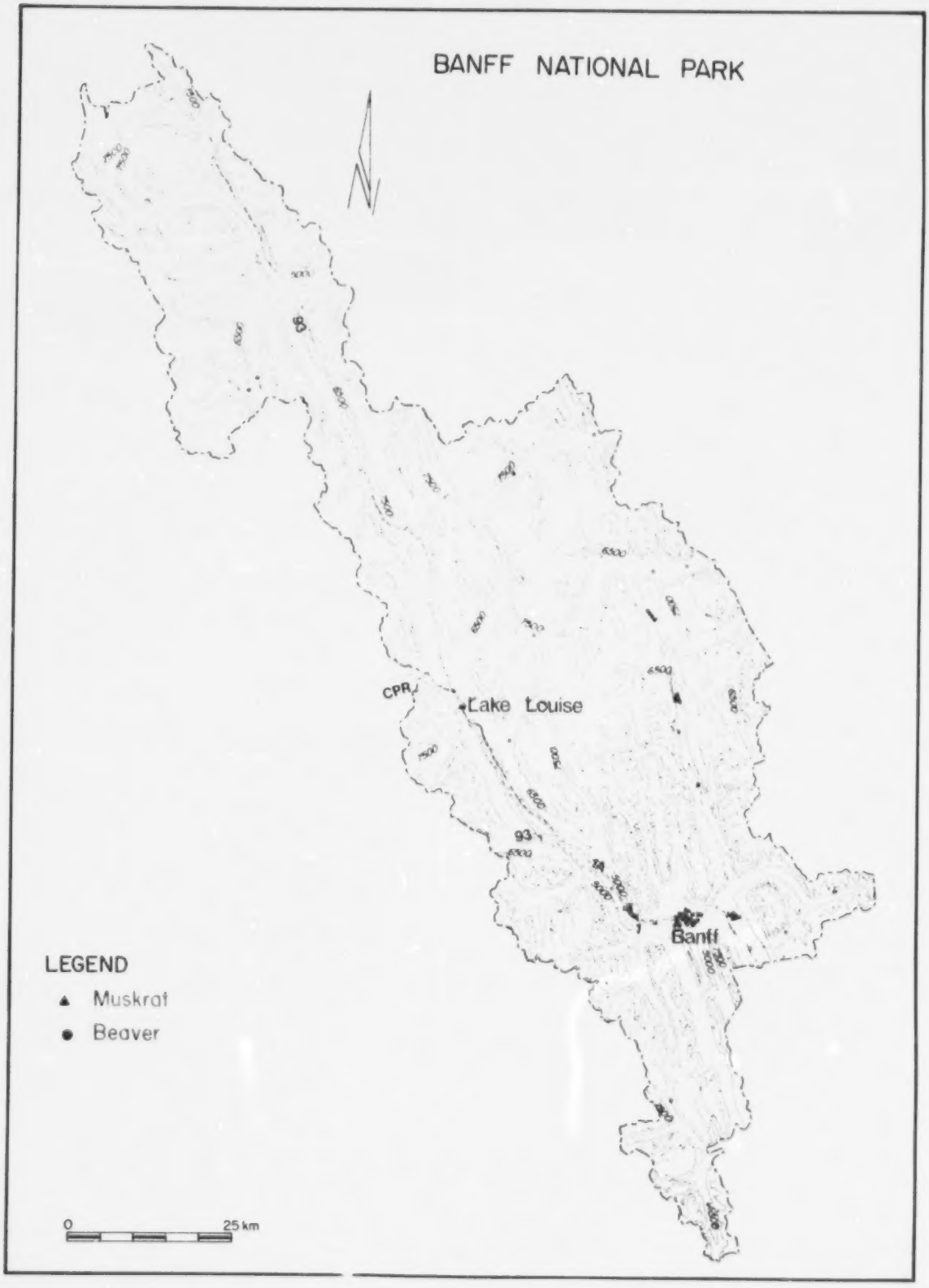
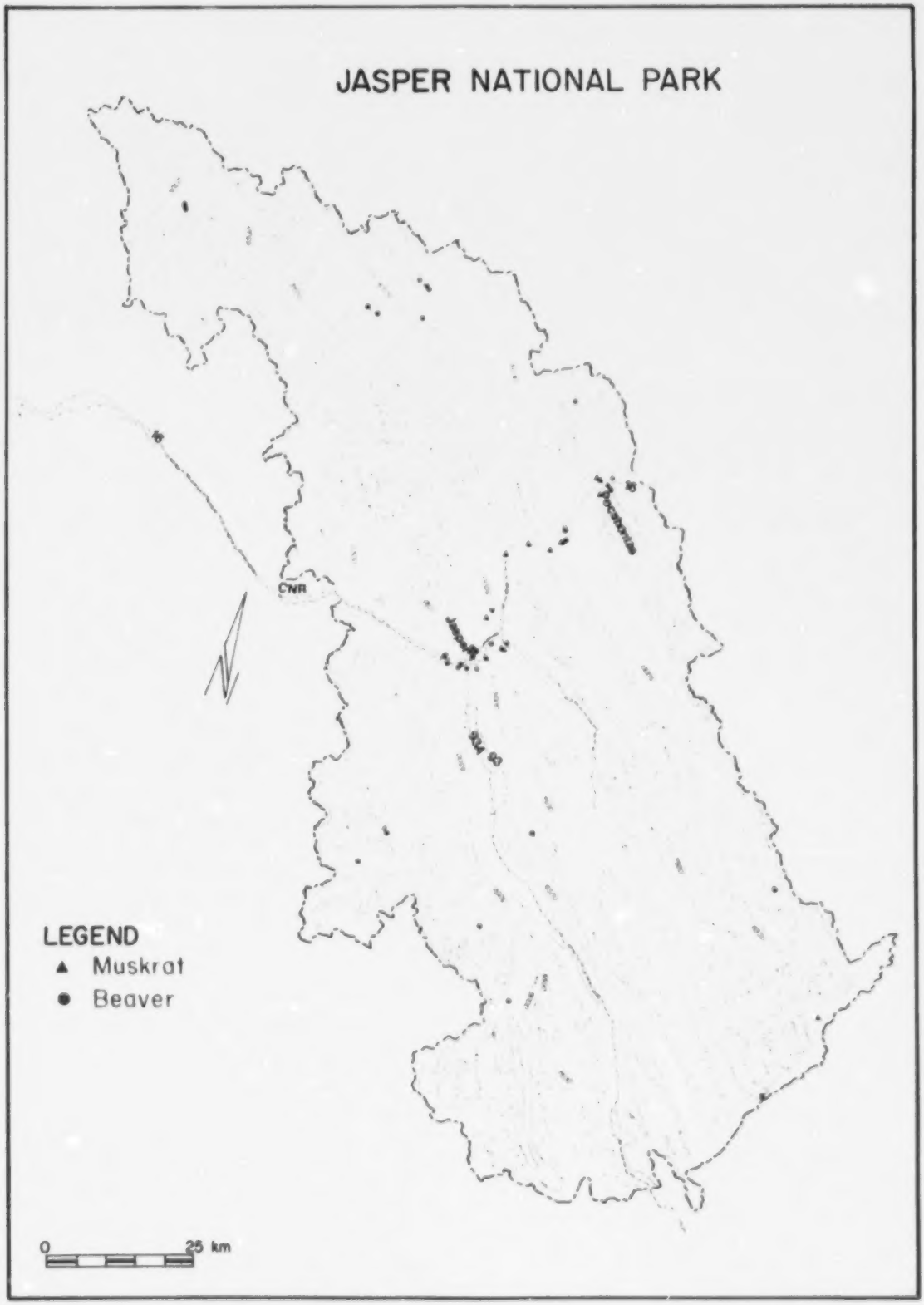


Figure 3.34. Distribution of beaver and muskrat observations in Jasper.



During this project, beavers were found to be common (three or more animals or five or more active locations seen) in the Bow River valley below Lake Louise, Panther River valley, Miette River ad lower Athabasca River valleys and the Rock Creek watershed. Higher densities are found in the eastern portions of the parks (Figure 3.33, 3.34) due to larger areas of suitable habitat in wider valley bottoms. A survey of food caches in the Bow valley between Lake Louise and the east gate of Banff revealed 11 caches. Nine of these were in the Banff townsite area. Green (1951b in Banfield 1958) traced a rise in beaver numbers in the Bow valley after 1920 and a decline in numbers as the food supply was reduced. Farris (1956) censused beavers in Banff National Park in the early 1950's and estimated a population of 255 beavers in the park. This estimate probably represents a peak in beaver numbers with all habitat occupied and productive. Beavers were common in the lower Bow River valley again in the winter of 1980/81, with some being sighted in marginal habitat such as Fortymile Creek above highway 1.

HABITAT

Beavers occur from the montane to the upper subalpine, but they are most common in the montane and lower subalpine, because most valley bottom (wetland) habitats are within these ecoregions. There were 25 sites in the montane, 28 in the lower subalpine and four sites in the upper subalpine where beavers or their sign were identified. Beavers are usually associated with alluvial and aquatic ecosites. Subalpine lakes and montane backwaters, floodplain ponds, kettles and scours are the aquatic habitats where beavers are most commonly found. The wetland habitats used by beavers may be surrounded by forest cover, shrub cover or herb cover but the vegetation at the edges of the wetlands is usually willow, poplar or other deciduous growth.

LIFE HISTORY

Beavers are most active during the night but may also be active on dark, quiet days. They are also active all winter. However, they only make an appearance out of water during winter if the colony is near starvation. Beavers are well known for their construction of dams and lodges; they also dig canals or channels and set up dens in bank tunnels, particularly along rivers. Mating occurs in January and February and kits are born between late April and late June. Shortly before birth of the kits, the male is driven out of the lodge by the female. Litter size ranges from one to eight. Young in their first summer do not share in the labors of the colony. During the second winter the young mature and in the following spring, they are driven out of the colony by the resident adults.

Predators of beavers include bears, wolves, coyotes, fisher, wolverines, lynx and cougars. Warden records indicate that predation by coyotes has been observed in the parks.

Beavers feed on leaves, twigs, buds, the cambium layer in tree bark and herbaceous pond vegetation. Aspen is the favorite tree for food, followed in preference by willows, white birch and balsam poplar. Beavers are forced to abandon the location of their colony when food supplies are exhausted. The supply of food is a major factor in the location of new colonies. About 0.4 ha of aspen forest will support a beaver for one year (Banfield 1974).

MANAGEMENT HISTORY

Beavers have been subjected to active management throughout the history of Banff and Jasper National Parks, largely because of their nuisance value.

In 1941, according to the Banff Advisory Council, beavers were causing areas west of Banff to become unsightly and rendering mosquito control difficult. Superintendent Jennings reassured the Council that the beaver colonies were a "... decided attraction for tourists" (National Archives, Ottawa), however in 1944 concern was expressed by Special Warden Green (1944) that mosquito control was harming beavers.

A controversy raged between the Warden Service and the mosquito contol crew from 1942 to 1948, during which time 1,111 dams were destroyed by the crew. In 1943 alone, the crew destroyed 235 dams and spread 3,553 gallons of motor oil and creoline on lakes and ponds (Archives of the Canadian Rockies).

During the 1940's poaching also became a problem in Banff, with 32 beavers taken in one season (Green 1944). The gradual decline of beaver numbers and the demise of the mosquito control program evidently solved most of these problems as they were not mentioned in park correspondence during the '50's.

Beavers were live-trapped in Banff during the 1940's to re-stock depleted areas in northern Alberta. Between 1944 and 1947 sixty were removed from the park, with 28 going to Indian Reserves near Lac la Biche in 1945 (Archives of the Canadian Rockies).

Beaver dams are still destroyed regularly where they block culverts along the CPR and CNR lines or, occasionally, flood roads and developed areas. The 1981/82 outbreak of *Giardia lambia* at Banff townsite was traced to beavers which had colonized Fortymile Creek upstream from the town water supply. The problem was temporarily solved by drawing water from wells already dug in a montane grassland in the autumn of 1981.

MANAGEMENT CONSIDERATIONS

While beavers are not always appreciated for the location of their dens and for the diseases to which they play host, they deserve protection and tolerance in national parks. Particularly in the mountains, valley bottoms become sites of conflict between beavers and human interests (roads, railroads, service facilities). The presence of beavers provides critical habitat for other animals such as fish, waterfowl, and moose by the creation of ponds and, in abandoned sites, wetland meadows. Where beavers occupy developed areas it may prove necessary to transplant troublesome dam-builders, to install special culverts through dams or under roads and to modify road construction methods around wetlands (Trottier 1974).

Beavers have high interpretive value - they are often sighted in such well-travelled areas as the Athabasca River and Vermilion Lakes. They are known to many for their engineering feats, as a fur bearer and for their role in the history and development of North America.

DEER MOUSE *Peromyscus maniculatus*

STATUS AND DISTRIBUTION

The distribution of deer mice in southern Canada reaches from the Atlantic Provinces to the islands off the British Columbia coast. The northern taiga is their northern boundary. Deer mice are also found throughout most of continental United States and on the Mexican Plateau.

Deer mice are widely distributed and abundant in Banff and Jasper. Occurring in a wide variety of habitats and often at high densities, this species is the most abundant mammal in both parks. In all snap trapping during the present project, there were 1647 deer mice (44% of total catch), 1001 red-backed voles and 290 meadow voles captured. The highest densities of deer mice estimated (Petersen Index) on live-trapping grids were 140/ha in white spruce groveland and 108/ha in an abandoned hay meadow. These high densities were in the montane but even in an alpine meadow there were 23 deer mice per hectare. Soper (1970) also found the deer mouse to be the most abundant small mammal in Jasper. Banfield (1958), however, felt that deer mice were not "... so common as some of the voles... " in Banff. While the red-backed vole can be more abundant in some areas than the deer mouse, this is not generally the case. Every watershed that

was sampled by snap trapping supported deer mice. Front Range watersheds tend to have higher numbers of deer mice. Trap lines that captured 25 or more deer mice were in the lower and middle Athabasca River, lower and middle Bow River, Brazeau River, lower Red Deer River, lower North Saskatchewan River and lower Snake Indian River watersheds. This distribution pattern may be related to drier conditions and more montane habitat in eastern portions of the parks. Fourteen out of 21 trap lines that caught 25 or more mice were located in the montane.

HABITAT

Deer mice occur from the montane to the alpine but their numbers decline as altitude increases. The average catch per 100 trap nights in ecosites in which this species occurred was 7.75 in the montane, 2.13 in the lower subalpine, 0.83 in the upper subalpine and 0.76 in the alpine. Deer mice are common in ecosites derived from fluvial and till material, particularly those that are relatively dry (xeric to mesic) and located on south-facing slopes. Vegetation types where deer mice are common are generally the more xeric types occurring in Banff and Jasper, including Douglas fir/hairy wild rye (C1) forest, white spruce forest, and aspen stands with understories of juniper, bearberry, hairy wild rye and pinegrass, as well as Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (04) forest. Deer mice are also common in herb mats of yellow avens and willow herb and meadows of fleabane and wormwood. A catch per 100 trap nights of 4.20 to 18.73 is considered high, 1.20 to 4.19 medium and 0.01 to 1.19 low.

LIFE HISTORY

Deer mice are mainly nocturnal. While they do not hibernate in winter, they do spend periods of time in torpor. Seeds are cached near the nest for winter food. Litters are born from May to August. Average litter size in the present study (based on embryo counts) was 5.36 (S.D.=1.17, N=58). There was no evidence that deer mice in Banff and Jasper National Parks have more than two litters per year.

In the mountains, deer mice fall prey to ground squirrels, Red squirrels, weasels, mink, bears, foxes, coyotes, wolves and owls. The most important predators are probably owls and weasels.

The main sources of food for deer mice are the seeds of grasses and forbs. Also eaten are conifer seeds, plant leaves, fruits, fungi, buds of trees and shrubs, insects and spiders (Williams 1959).

MANAGEMENT CONSIDERATIONS

Found in many habitats and exhibiting high reproductive potential, deer mouse populations are rarely threatened.

Deer mice thrive in disturbed areas in close proximity to man. For many people, deer mice co-exist with man all too well, readily making their way into back packs or buildings to sample stores of food. This contact with people gives the species interpretive value for park visitors.

BUSHY-TAILED WOOD RAT *Neotoma cinerea* BURA

STATUS AND DISTRIBUTION

The Bushy-tailed wood rat occurs in Canada in the mountains of British Columbia, the southern Yukon Territory and western Alberta Its range extends southward into the United States to central California and Utah.

The wood rat is widespread in Banff and Jasper, but it is uncommon, nocturnal, and rarely seen. There appears to be a geographic grouping of observations into four areas of adjacent watersheds but these do not show a correlation with the Main Ranges, Front Ranges or a north-south axis. One group is in northern Jasper including the Smoky River, Blue Creek and Willow Creek watersheds; another observation group is in central Jasper including the lower and middle Maligne River, the middle Athabasca River and the Astoria River watersheds; another group is in southern Jasper and northern Banff including the lower Brazeau River, Sunwapta River, upper and lower North Saskatchewan River, Alexandra River, Mistaya valley and Clearwater River watersheds and a fourth group of observations is in southern and south-eastern Banff including the middle and lower Bow River. Panther River, and lower and upper Spray River watersheds The wood rat was described by Banfield (1958) as being "widely distributed in Banff Park in suitable habitat" and by Soper (1970) as being "well represented locally and apparently lacking in many scattered tracts of country" in Jasper National Park. Banfield's and Soper's impression of the status of the wood rat is consistent with the data collected during the present project.

HABITAT

The Bushy-tailed wood rat has been observed from the montane to the upper subalpine. During the present project, there were nine animals or sites with sign (nests or scats) observed in the montane, 15 in the lower subalpine and two in the upper subalpine. Wood rats frequent a wide range of ecosites including some derived from till, fluvial, colluvial or glaciofluvial material with tree cover dominated by lodgepole pine, Engelmann and white spruce. Wood rats inhabit rocky areas (cliffs, ledges, rock talus, canyons, caves and abandoned mine shafts), areas with overhanging tree roots such as stream banks and areas with accessible abandoned buildings.

LIFE HISTORY

Although occasionally observed during the day, the wood rat is essentially nocturnal, with peaks of activity around sunset and dawn. It remains active in winter under snow. A strongly territorial species, wood rats are primarily solitary except during the breeding season. The peak of the breeding season is between March and June. Wood rats may have two litters per year but they probably have only one litter in the mountain parks. Average litter size in a laboratory colony was 3.5 with a range of one to six young (Esoscue 1962). Dens are built in cabins, mine shafts, under cliffs, in caves and in rock crevices.

Wood rats are preyed upon by great horned owls, wolverines, marten, weasels, wolves, coyotes and foxes.

Wood rats feed on the foliage of a variety of trees, shrubs and forbs. In autumn, food caches are built up for winter use.

MANAGEMENT CONSIDERATIONS

Occurring in rocky habitats, bushy-tailed wood rats are not often disturbed by people. This may not be the case where wood rats nest in caves or where they gain access to an isolated cabin. While access to cabins may have to be closed to prevent wood rat damage, climbers and cavers should be discouraged from disturbing wood rat

caves.

GAPPER'S RED-BACKED VOLE *Clethrionomys gapperi* GAVO

STATUS AND DISTRIBUTION

In Canada, the red-backed vole is found from Labrador to British Columbia and north to Great Slave Lake in the Northwest Territories. It is absent from prairie grasslands. The southern boundary of the range reaches from New England in the Appalachian Mountains, to Minnesota, North Dakota and Montana, and almost to Mexico in the Rocky Mountains.

The red-backed vole is widespread and generally common in Banff and Jasper. Populations exhibit cyclic fluctuations. At population peaks, this vole may become the most common small mammal in the parks, exceeding the numbers of the abundant deer mouse. Red-backed voles reach densities of up to 28/ha in lodgepole pine-alder woodland, 21/ha in tall willow woodland and 15/ha in spruce forest (from live trapping in late July and early August). In these habitats favored by red-backed voles, deer mice occur at densities of 18/ha, 37/ha and 3/ha respectively. There were 1001 red-backed voles captured in all snap trapping (27% of all captures) compared to 1647 deer mice. This is equivalent to an average catch per 100 trap nights of 2.50 for deer mice and 1.52 for Gapper's red-backed voles. Red-backed voles were trapped in almost all watersheds that were sampled by snap trapping. Exceptions were the upper Cascade River (one trapline), Howse River and Glacier River (four traplines) and Pipestone River (one trapline). Lack of records from these watersheds is probably related more to small sample size rather than to absence of the species. High capture rates (twenty or more voles per trapline) were obtained in the Nigel Creek watershed and in the lower, middle and upper Bow valley.

The red-backed vole is more common in Banff than in Jasper; the average catch per 100 trap nights of this species in all Banff traplines was 2.17 and in all Jasper traplines was 1.32 animals. A difference between parks is indicated in the comments of Soper (1970) and Banfield (1958). While Soper found red-backed voles in only seven of his 20 study sites in Jasper National Park, Banfield called this vole "the commonest small mammal" in Banff National Park.

HABITAT

Red-backed voles in the mountain parks occur from the montane to treeline in the upper subalpine ecoregion. Red-backed voles were twice caught in alpine traplines near timberline. Ecosites with high numbers of voles were in the montane (3 ecosites), lower subalpine (24 ecosites) and upper subalpine (4 ecosites). Most ecosites with high numbers of voles (19 of 31) are derived from glacial till. High numbers of voles occur in mature forests of Engelmann spruce, lodgepole pine, white spruce and subalpine fir, particularly on cool, mesic sites and on north-facing slopes.

Several authors (in McManus 1974)) also found red-backed voles commonest in moist conifer forests with mossy ground cover. Powell (1972) associated Gapper's red-backed voles with deadfall. Rocky areas and disturbed areas are avoided.

Average catch per 100 trap nights in pine, spruce or subalpine fir forests with mossy understories (C10, C11, C13, C26) is 4.00 whereas drier Douglas fir/hairy wild rye (C1) forests have capture rates of only 0.30 per 100 trap nights and aspen forests (C16, C22) have no captures. Open forests and other cover types have capture rates well below those found in the closed conifer forest.

A catch per 100 trap nights of 2.668 to 10.272 is considered high, 0.710 to 2.667, medium and 0.001 to 0.709 low.

LIFE HISTORY

Red-backed voles are active throughout the year. On a daily basis, they are mainly nocturnal but also make frequent appearances during the day. While families often congregate during the winter, adults lead solitary lives in summer. The breeding season is from April to October. Peaks in numbers of births occur in May, July and September. Adult females can have three or sometimes four litters per year. Young females may mature in their first summer and bear one or two litters. Voles captured during this project had at least two litters and some of the overwintered voles probably had three litters. Average litter size is 5.66 (S.D.=1.23, N=1.74) based on embryo counts.

Because of its large numbers and activity throughout the day and year, the red-backed vole is a major food source for predators, including the Long-eared Owl, Great Horned Owl, Barred Owl, Rough-legged Hawk, weasels, American marten, mink, Red fox, Black bear and Red squirrel.

Gapper's red-backed voles are omnivorous. They eat plant material, animal carcasses and some insects. The spring diet consists largely of the shoots of growing plants. In summer, fungi and a variety of berries are eaten and in autumn the diet is mainly seeds. Food is not stored for winter, when petioles, twigs, winter buds and green leaves are eaten.

MANAGEMENT CONSIDERATIONS

Populations of red-backed voles are rarely threatened because numbers are usually high. This species is very important as a prey species for a number of carnivores.

NORTHERN BOG LEMMING *Synaptomys borealis* **NOLE**

STATUS AND DISTRIBUTION

The Northern bog lemming occurs across North America from Labrador on the east coast to British Columbia and Alaska on the west coast.

This species is uncommon in Banff and Jasper. While 1647 deer mice and 1001 red-backed voles were taken in snap traps during this project, there were only 47 bog lemmings taken (1.25% of all captures). The average catch per 100 trap nights in traplines where bog lemmings were captured was 1.41 lemmings in Banff but only 0.64 in Jasper.

Most bog lemming specimens come from the upper Bow River (19) and middle Bow River (12) watersheds, and because of the large catches in these areas, the total catch of bog lemmings in Banff was greater than that in Jasper. In Jasper, bog lemmings were trapped in the Astoria River (1), lower Athabasca River (1), Miette River (1), upper Rocky River (2), Sunwapta River (1) and Whirlpool River (2) watersheds. In Banff, specimens were taken in the upper Cascade River (2), lower North Saskatchewan River (4), Siffleur River (2) and upper Spray River watersheds

Soper (1970) described this species as "one of the very rarest of Jasper Park mammals" but Banfield (1958) concluded that the few specimens collected in Banff underestimated bog lemming numbers.

HABITAT

The Northern bog lemming occurs from the montane to the upper subalpine. The elevation of captures ranged from 1340 m to 2290 m and averaged 1980 m. There was one bog lemming trapped in the montane, 15 in the lower subalpine and 34 in the

upper subalpine. The highest numbers of bog lemmings occur in ecosites derived from till material, having cold, poorly-drained soils. This species occurs in Engelmann spruce-subalpine fir forests with shrubby understories, willow thickets, wet herb meadows and sedge fens. The average catch per 100 trap nights was 0.62 in wet subalpine areas with herb or shrub cover (H9, H10, H11, H16, S1, S3, S4, S5, S7, S8, S11). No bog lemmings were captured in well-drained areas with shrub or herb cover (H8, S2, S9, S10). A catch per 100 trap nights of 0.340 to 1.579 is considered high, 0.144 to 0.339 medium and 0.001 to 0.143 low.

LIFE HISTORY

The Northern bog lemming is active throughout the year and throughout the day. The breeding season is from May to August. Litter sizes range from two to seven with an average of 4.8 embryos (S.D.=1.26, N=15) per litter. Bog lemmings may breed in their first summer. Foods of this species include grasses and sedges. Predators probably include hawks, owls and mustelids.

MANAGEMENT CONSIDERATIONS

Drainage of wet sites will reduce bog lemming habitat. Basic natural history research is still needed for this species.

HEATHER VOLE *Phenacomys intermedius* HEVO

STATUS AND DISTRIBUTION

The heather vole occupies a band of territory across Canada from Labrador to the Yukon Territory and south in the Rocky Mountains to New Mexico.

This vole is widely distributed in Banff and Jasper. It is generally uncommon but may be locally common in appropriate habitat. There were 196 heather voles captured in snap traps during this project (5% of all captures) as compared to 1001 red-backed voles, 290 meadow voles and 140 long-tailed voles. The average catch per 100 trap nights among ecosites sampled by snap traps was 0.32 for the heather vole, 1.48 for the red-backed vole and 0.05 for the northern bog lemming. Heather voles are found throughout the parks. Almost all watersheds that were sampled by snap trapping had heather voles. The exceptions where three or more traplines failed to capture a vole were the Baker Creek, lower Brazeau River and south fork of the Brazeau River, Cairn River, Johnston Creek and lower Snake Indian River watersheds, all in the Front Ranges. It appears that watersheds in the eastern portions of the parks may have somewhat fewer Heather voles; in a comparison of traplines located east of highways 93 and 1 with those west of these highways, the average catch per 100 trap nights was 1.20 in western traplines and 1.11 in eastern traplines.

HABITAT

Heather voles occur from the montane to the alpine. Among ecosites that were sampled by snap trapping, the average catch per 100 trap nights was 0.14 in the montane, 0.24 in the lower subalpine, 0.54 in the upper subalpine and 0.47 in the alpine. Highest numbers of heather voles were taken in ecosites derived from till material and ranging from hygric valley bottoms to xeric, south-facing slopes. Vegetation in heather vole habitat is varied. In moist sites this species can be found in closed forests of subalpine larch or white spruce or in shrubby open forests of subalpine fir with Engelmann spruce or subalpine larch and willow, mountain avens and heather. In wet sites it occupies willow thickets and sedge meadows. In dry sites Heather voles frequent Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) forests, shrubby cinquefoil/bearberry-northern bedstraw (L1)slopes, dry grasslands and alpine tundra. While

Heather voles will occupy dry, exposed habitats, within those habitats they are usually near water and in areas providing cover in the form of low shrubbery or grasses, sedges and other herbs.

A catch per 100 trap nights of 0.549 to 2.177 is considered high, 0.278 to 0.548 medium and 0.001 to 0.277 low.

LIFE HISTORY

Heather voles lead solitary lives in summer except during breeding. In winter litter mates gather in communal nests. This species is active at twilight and during the night particularly on cloudy nights. It remains active all winter under the snow cover. The breeding season is from May to August and litters are born from mid-June to early September. Mean litter size is 4.36 (S.D.=1.27, N=50) based on embryo counts. Young males do not mature in their first year but young females may have a litter in the summer of their birth.

Predators of the heather vole include the Rough-legged Hawk, Short-eared Owl, Snowy Owl, Hawk Owl, marten and weasels (Foster 1961).

Heather voles cache food for winter use. Winter food consists of the bark and buds of shrubs and heaths (e.g. willow, dwarf birch, heather). In summer, the green foliage, berries and seeds of grasses, shrubs (e.g. aspen, wild rose, willow, buffaloberry, dwarf birch), heaths (e.g. bearberry, cranberry, crowberry) and forbs (e.g. lousewort, strawberry, vetch) are eaten (Foster 1961).

MANAGEMENT CONSIDERATIONS

In areas where suitable habitat for heather voles is limited, human activity may reduce numbers of voles, since human activity tends to concentrate in preferred vole habitats such as steamsides, forest edges and meadows.

MUSKRAT *Ondatra zibethicus* **MUSK**

STATUS AND DISTRIBUTION

Muskrats occupy an extensive range in North America from the southern United States to northern Canada. Included in their northern range are most of Alaska, the Yukon Territory and the Mackenzie District of the Northwest Territories.

This rodent is common only in very restricted areas and is otherwise generally absent in the mountain parks. The areas where muskrats occur tend to be the lower portions of main valleys where rivers are slow-moving and where emergent vegetation can be found (Figure 3.33, 3.34). The highest number of muskrats (100) was reported in the Vermilion Lakes area (Bow Valley Naturalists 1978). No other area in Banff and Jasper supports so large a population of muskrats.

HABITAT

Muskrats occur from the montane to the upper subalpine. During the present project, there were 66 records in the montane, 11 in the lower subalpine and 8 in the upper subalpine. Montane observations were all from alluvial wetlands. Muskrats frequent alluvial wetlands with sedge beds and seasonally flooded willow stands, as well as the edges of lakes and slow streams where extensive stands of suitable vegetation are available. Suitable vegetation includes stands of sedge, water milfoil, pondweed and grasses such as bluejoint and tufted hairgrass; and stands of shrubbery including dwarf birch, shrubby cinquefoil and willows. For muskrats to survive in a wetland all year, the

lakes, ponds, rivers or marshes should be at least 1.5 m deep so that the water will not freeze to the bottom in winter but should not be deeper than 3.5 m, so that submergent vegetation can grow. Most of the occupied wetlands in the mountains are below 1240 m altitude. A small colony in Wigmore Lake, at the upper limit of the lower subalpine, is an exception.

LIFE HISTORY

Muskrats are mainly nocturnal or crepuscular but may also be found feeding during cloudy days. This rodent goes through two peaks of dispersal each year. The need for adequate water depth in winter is reason for the dispersal which occurs in autumn and territoriality in spring causes the second dispersal. The breeding season lasts from March to September and the first litter is born in late May. Litter size ranges from one to eleven young. An adult female can have two litters per year in northern Canada and yearling females can have one litter.

Predators of muskrats occurring in the mountain parks include mink, foxes, coyotes, wolves, black bears, lynx, great horned owls, goshawks, and bald and golden eagles.

Besides emergent vegetation (cattail, bulbrush, sedge, pondweed, etc.), the summer diet of muskrats can include such animal material as cannibalized muskrat young, frogs and salamanders. There is no storage of food for winter use. In winter, muskrats feed on submergent vegetation such as pondweeds, water weed, bladderwort and bur reed.

MANAGEMENT CONSIDERATIONS

Suitable habitat for muskrats in the mountain parks is limited. Changes in habitat quality in the Vermilion Lakes, lower Miette valley and the wetlands from Talbot Lake to Pocahontas could result in the exclusion of this species from the mountain parks. Maintenance of a muskrat population is dependent on natural water regimes in montane marshes and rivers, with periodic heavy flooding to retard plant succession (D.M. Poll, pers. comm.).

Muskrats are often visible to park visitors, are known for their valuable pelts and role in Canada's fur trade, and are thus of interpretive interest.

RICHARDSON'S WATER VOLE *Arvicola richardsoni* **WAVO**

STATUS AND DISTRIBUTION

In Canada, Richardson's water vole is found in the southern Rockies and in south-central British Columbia. The range of the water vole extends southward in the mountains into the northern United States.

The water vole is rare to uncommon in Banff and Jasper. In Jasper, water voles were found in two areas - in the north in the Smoky River and Blue Creek watersheds and in the south-west in the Astoria River, Whirlpool River and upper Athabasca River watersheds. In Banff Richarson's water voles were recorded through the southern half of the park in the upper Spray River, Johnston Creek, Panther River, Pipestone River, Healy Creek and upper and middle Bow River watersheds. The highest number of water vole observations were in the Blue Creek, upper and middle Bow River, and Pipestone River watersheds. Salt (1978) described the distribution of water voles as being centered in the area from the southern boundary of Banff National Park south to Waterton Lakes; north of Lake Louise, he described this species as "... very widely separated in occurrence", but this underestimates water vole numbers in the upper Bow River valley and in northern Jasper. Soper (1970) and Banfield (1958) considered the water vole to

be rare in both parks.

HABITAT

The Richarson's water vole occurs from the alpine to the lower subalpine. During the present project, water voles or their sign were observed at 29 sites – two were in the lower subalpine, 22 were in the upper subalpine and five were in the alpine. The ecosites in which Richarson's water voles were recorded are derived from glacial till, alluvial or glaciofluvial parent materials, are moist, and generally receive heavy accumulations of snow or late snow lie on north-facing slopes. Water voles occupy open subalpine fir, subalpine larch or Engelmann spruce forests, alpine heath tundra, moist herb meadows of fleabane and valerian and relatively dry *Kobresia*-fescue grassland. The common features of Richarson's water vole habitats are well-developed herb and shrub layers and proximity to water.

LIFE HISTORY

The Richarson's water vole is a semi-aquatic rodent and is an excellent swimmer and diver. It is colonial and remains active throughout the 24-hour period, particularly at night, as well as throughout winter under the snow. Breeding begins as early as mid-May and continues into mid-September in the Front Ranges of the Rockies in Alberta (D.R. Ludwig, pers. comm.). Overwintered females live through one breeding season when they have one or two litters. Juvenile females of the first litter of the summer usually mature to have a small litter in their first summer. Banfield (1974) lists an average litter size of five with a range of two to eight young. Salt (1978) found an average litter size of four (range of three to five). Anderson and Rand (1943) counted 7.7 and 8 embryos in adult females and 4 embryos in a young female. In the present project, autopsy of four female water voles revealed litter sizes of 4, 6 and 8 by embryo counts and 8 by placental scar count, for an average litter size of 6.5 young.

Food plants include herbs such as valerian, lousewort, arnica, sneezeweed, lupine, knotweed, fleabanes, glacier lilies, everlasting, sedges and grasses, and willow bark and buds (Salt 1978).

Because of its limited distribution and perhaps because it is not an important prey species, the predators of the water vole are not well known. Grizzly bears probably prey on water voles as their diggings have been associated with water vole tunnels. Coyotes, lynx and short-tailed weasels have been observed hunting or digging in areas of vole activity (Salt 1978). Hawks, owls, golden eagles, marten and wolves are probable predators.

MANAGEMENT CONSIDERATIONS

In order to maintain vole numbers, compaction of snow, trampling of vegetation, and alteration of drainage should be kept to a minimum in shrubby, wet, upper subalpine meadows. By removing the tree cover logging may increase water vole numbers (Hoover 1973). In a national park, forest fire may have a similar effect.

Usually an uncommon species of subalpine meadows, water voles occasionally occur in large numbers and descend into valleys, inflicting damage in agricultural district (Racey 1960). Population eruptions of this sort have not been recorded in Banff and Jasper.

MEADOW VOLE *Microtus pennsylvannicus* **MEVO**

STATUS AND DISTRIBUTION

The meadow vole occupies much of North America. It occurs in all parts of Canada except western British Columbia, the arctic islands and the northeast of the District of Keewatin in the Northwest Territories. The northern half of the United States, except for Washington and Oregon, is also inhabited by this vole.

The meadow vole is widespread in Banff and Jasper but although it is generally common, its numbers fluctuate from year to year. From live trapping, a very high density of 108 animals per hectare was recorded in August in a grassland adjacent to the Palisades training centre in Jasper. Densities of 21/ha were found in tall willow woodland and 18/ha in a black spruce bog. This is the third most abundant mammal in the mountain parks. There were 290 meadow voles captured during this project (8% of all captures) as compared to 1647 deer mice, 1001 red-backed voles, 196 heather voles and 140 long-tailed voles. In all ecosites sampled by snap trapping, there was an average catch per 100 trap nights of 0.42 meadow voles as compared to 3.06 deer mice and 0.22 long-tailed voles. Three or more traplines did not capture a meadow vole in the Alexandra River, upper Athabasca River, Baker Creek, Healy Creek, Johnston Creek, upper North Saskatchewan River, Nigel Creek, upper Red Deer River and upper Spray River watersheds but failure to capture can in most cases be attributed the habitat types sampled in these watersheds, rather than to an absence of Meadow voles. Traplines that did capture meadow voles usually captured one to five voles. Three traplines captured more than 20 voles - two were in the lower Athabasca River valley and one was in the Cairn River valley.

HABITAT

Meadow voles occur from the montane to the alpine. In ecosites where meadow voles were trapped, the average catch per 100 trap nights was 0.61 in the montane, 0.75 in the lower subalpine and 1.17 in the upper subalpine. Only one animal was captured in the alpine during this project. Among the 75 snap trap samples which included meadow voles in their captures, one was in the alpine (2320 m altitude), 18 were in the upper subalpine, 36 were in the lower subalpine and 20 were in the montane. High capture rates (over 0.34/100 trap nights) were found in ecosites based on fluvial and till material. Moisture conditions in these ecosites tend to be mesic to hygric but in some areas, subxeric conditions were prevalent. Meadow voles occur most often in shrubby or herbaceous cover. The common shrubs include willows, dwarf birch, alder, shrubby cinquefoil, buffaloberry and bearberry, but while shrub cover is characteristic of many vegetation types used by meadow voles, grass and sedge species are probably more important in habitat selection by the voles. Getz (1961) found that meadow voles in Michigan occur in habitats in which the plants are mainly grasses and that they avoid woody plants and areas supporting only forbs. Morse (1973) found that meadow voles are absent from continuous spruce forests having no grasses except when densities are very high. The average catch per 100 trap nights in this project was 0.07 in coniferous forests with extensive moss cover (C2, C5, C10, C11, C13, C14, C15, C21), 0.24 in coniferous forests with both moss and grass or sedge cover (C18, C19, C31) and 1.01 in coniferous forests with grass or sedge cover (C8, C9, C27). A catch per 100 trap nights of 0.841 to 8.443 is considered high, 0.267 to 0.840 medium and 0.001 to 0.266 low.

LIFE HISTORY

Meadow voles often appear to be colonial. However, this vole is socially aggressive and appearances of a colonial social structure result from the concentration of large numbers of voles in favored habitats. The type of activity patterns exhibited by *Microtus* is disputed (Ambrose 1973) but apparent peaks of activity occur before sunset and again after sunrise. This vole stores food for winter use. The breeding season is

from May to September. During this project, embryo counts on autopsied females revealed a range in litter size from three to nine and an average of 5.14 (S.D.=1.51, N=73). Banfield (1974) lists an average litter size of 6.3 for this species. Overwintered females appeared to have at least 2 or 3 litters in a summer. First litter young can mature to produce a litter in the summer of their birth. Young females can mature at about 25 days and give birth to a litter at about 45 days. Young born in early summer produce a late summer crop of young but these mature young-of-the year voles do not seem to survive to the next breeding season with their young.

The meadow vole has many predators due to its occurrence over a large part of North America and its occupancy of numerous habitat types. It is the main prey of marten in British Columbia (Quick 1955) and the Alberta Rockies (Cowan and MacKay 1950). During this project, predation on Meadow voles by Coyote, Saw-whet Owl and Pygmy Owl was recorded. In the mountains, predators of the meadow vole probably also include the weasels, mink, badger, fox, bears, hawks, other owls, crows, magpies, jays, shrikes and gulls.

The main food sources of this vole are grasses, sedges and some forbs. A few insects and snails are eaten and cannibalism is also known to occur. Under conditions of food shortage and large population size, voles will strip bark from the roots, stems and twigs of woody shrubs and saplings, and this food source is commonly used in Banff and Jasper in winter.

MANAGEMENT CONSIDERATIONS

The meadow vole is not a threatened species in Banff and Jasper. However, as an important prey species, high importance must be accorded to productive meadow vole habitat such as the grassy meadows near the Palisades training centre. While meadow voles often compete with such facilities as campgrounds for habitat in the montane and lower subalpine, developments such as roads with wide, grass-covered embankments create large areas of new habitat. Dogs and particularly cats will prey on this vole. The quality of meadow vole habitat is reduced by heavy grazing, foot traffic in summer and by snow compaction in winter.

LONG-TAILED VOLE *Microtus longicaudis* **LOVO**

STATUS AND DISTRIBUTION

The range of the Long-tailed vole extends from southeastern Alaska through British Columbia, the Yukon Territory and western Alberta south in the United States to northern California and Arizona.

The Long-tailed vole is widespread in Banff and Jasper. In northern Jasper there are no records of this vole but this is probably due to the low sampling effort in this area. It is generally rare or uncommon where it has been recorded. Traplines that did capture this species usually only took one to three specimens. One trapline took 21 Long-tailed voles near Whitehorse Pass, and two traplines in the middle Bow River valley took 11 voles each. Watersheds where traplines which captured five or more Long-tailed voles were the upper Athabasca River, middle Bow River, Fiddle River, upper North Saskatchewan River, and upper Rocky River. Watersheds with no records of long-tailed voles but which were sampled by four or more traplines were the upper Bow River, lower Cascade River, Healy Creek, lower Maligne River, Mistaya River, Panther River, lower Red Deer River and lower Rocky River. Among the small mammals of Jasper National Park, Soper (1970) considered this vole to be fifth in abundance. The 140 specimens of this species taken in snap traps during this project (4% of all captures) also places the vole in fifth place among small mammals of Banff and Jasper. In fourth place was the Heather vole (196 specimens) and in sixth place was the Western jumping mouse

(116 specimens). In all ecosites sampled by snap trapping, the average catch of Long-tailed voles per 100 trap nights was 0.22 as compared to 0.42 for the meadow vole or 3.06 for the deer mouse.

HABITAT

Long-tailed voles occur from the montane (1400 m) to the alpine (2320 m). In ecosites where this vole was trapped, the average catch per 100 trap nights was 1.02 in the montane, 0.73 in the lower subalpine, 0.76 in the upper subalpine, and 0.30 in the alpine. Catches of Long-tailed voles were high (over 0.84 per 100 trap nights) in ecosites derived from till and colluvial materials, especially on steep, well-drained (mesic to xeric) south-facing slopes. On mesic sites, high Long-tailed vole numbers occur in lodgepole pine forest with understories of juniper and bearberry, in aspen/hairy wild rye-peavine (C16) forest, in open spruce-fir forest and in willow thickets. The more xeric vegetation types used by Long-tailed voles include open limber pine or Douglas-fir forests with juniper and grasses, and shrub thickets of dwarf birch, willow and shrubby cinquefoil. Long-tailed voles are also common on avalanche slopes with aspen stands and dense shrubbery. The common factor in vegetation types used by Long-tailed voles appears to be the dominance of grasses in the understory and abundant cover in the form of dense shrubbery or deadfall. A catch per 100 trap nights of 0.840 to 3.933 was considered high, 0.293 to 0.893 medium and 0.001 to 0.292 low.

LIFE HISTORY

The Long-tailed vole has received little study. Its habits are similar to those of the meadow vole (Banfield 1974).

Long-tailed voles are diurnal and are active all winter. Wide population fluctuations are common with this species. The breeding season lasts from May to August. Voles autopsied in this project showed that this species has at least two litters per year. Litter size ranges from two to six with an average of 4.80 embryos per litter (S.D.=1.26, N=15).

Specific food plants and predators are not known for this species. Because it occupies similar but somewhat drier habitats and shows similar activity patterns to the meadow vole, it probably finds sustenance from similar plants (grasses and some herbs) and falls prey to the same predators (owls, hawks and mammalian carnivores) as the meadow vole.

MANAGEMENT CONSIDERATIONS

Avalanche debris and grassy areas in forest glades and along stream banks are favored habitats for long-tailed voles. Such habitats are not abundant and should be protected.

Banff and Jasper provide ideal locations for studies of undisturbed populations of Long-tailed voles. Unlike other small rodents, the natural history of this species is poorly known, due in part to its limited range and the lack of accessible study areas.

HOUSE MOUSE *Mus musculus* hypothetical — HOMO

STATUS AND DISTRIBUTION

The house mouse occurs in settled areas across Canada as far north as the Mackenzie Delta (Banfield 1974). There have been no documented records of the species in either Banff or Jasper. One was trapped in Canmore, just east of Banff National Park, in October 1980 (GLH). House mice may be expected to occur in townsites and railyards.

HABITAT

This species frequents houses, warehouses, garbage dumps and railyards where it forages largely on human foodstuffs. It is rarely seen in the wild although it may colonize dry grasslands and agricultural areas (Banfield 1974).

MANAGEMENT CONSIDERATIONS

This species is unlikely to become a management problem in the parks due to its restrictive habitat needs. It is readily controlled by proper storage of food and garbage and, where necessary, by trapping.

WESTERN JUMPING MOUSE *Zapus princeps* — WEMO

STATUS AND DISTRIBUTION

The Western jumping mouse ranges through western North America from the southern Yukon Territory to New Mexico.

This mouse is widespread but uncommon in Banff and Jasper. During this inventory 116 jumping mice were trapped (3% of all captures) as compared to 1647 deer mice and 1001 red-backed voles. The average catch per 100 trap nights in all ecosites sampled by snap trapping was 0.21 for jumping mice, 3.06 for deer mice, 1.48 for red-backed voles and 0.42 for meadow voles. Watersheds sampled by five or more traplines that failed to produce any jumping mice were the middle Athabasca River, lower Cascade River, lower Maligne River, Nigel Creek, and lower Red Deer River. A single trapline rarely produced more than one or two jumping mice. Traplines that captured four or more jumping mice were in the middle Bow River, upper Athabasca River, Healy Creek, Poboktan Creek, Sunwapta River and Whirlpool River valleys.

HABITAT

Western jumping mice occur from the montane (1010 m) to the upper subalpine (2320 m). Banfield (1958) also found this species from the valley bottoms to the treeline in Banff National Park. In ecosites where jumping mice were trapped, the average catch per 100 trap nights was 0.30 in the upper subalpine, 0.59 in the lower subalpine and 0.26 in the montane. Ecosites with the highest densities of jumping mice (above 0.57/100 trap nights) are derived from till, fluvial and colluvial material with wet (mesic to hygric) soils and lush, species-rich herb layers. Vegetation types supporting high densities of Western jumping mouses include lodgepole pine forests with juniper and bearberry, closed white spruce forests with buffaloberry and moss, open Engelmann spruce - subalpine fir woodland with willows and sedges, shrubby, herb-rich avalanche slopes, alder thickets with thimbleberry, and willow thickets with shrubby cinquefoil. Brown (1970) found the western jumping mouse in the lush, herbaceous vegetation of wet meadows, bogs, streamsides and lake margins. A catch per 100 trap nights of 0.571 to 2.381 is considered high, 0.279 to 0.570 medium and 0.001 to 0.278 low.

LIFE HISTORY

The Western jumping mouse is primarily nocturnal. When the summer seed crop becomes available, fat is stored for the September to May hibernation period (Cranford 1978). An average jumping mouse lives through two summers but survivors to a fourth summer have been recorded (Brown 1970). Mountain populations have one litter per year. Birth of the single litter occurs between mid-June and late July. Banfield (1974) quotes a range in litter size from two to seven with an average of five young. Females autopsied in the present project revealed an average litter size of 4.50 (S.D.=0.57, N=4) based on embryo counts of 3.92 (S.D.=1.24, N=12) based on embryo and placental scar counts.

Hawks, owls, weasels, foxes and coyotes are the main predators of jumping mice in the mountains. Predators seem to be unable to locate hibernating animals (Brown 1970).

Grass seeds and the summer berry crop constitute the main diet of the jumping mouse.

MANAGEMENT CONSIDERATIONS

Western jumping mice are more vulnerable to drastic reductions in numbers because of lower reproductive capacity (one litter rather than two to four annually) than other small mammals. Seed crops are necessary in this species' diet for overwintering fat deposition (Cranford 1978). As mortality at the time of hibernation is already high under natural conditions (Brown 1970), destruction of habitat and particularly seed crops may bring about drastic declines in populations. Meadows near streams, lakes and avalanche slopes should not be subjected to excessive grazing and trampling.

AMERICAN PORCUPINE *Erethizon dorsatum* **PORC**

STATUS AND DISTRIBUTION

The porcupine is widespread in Banff and Jasper. It is currently common throughout the parks with the exception of southern Banff where few observations have been recorded (Figure 3.35, 3.36). Winter track count transects revealed porcupine activity in the following watersheds:

Alexandra River
Astoria River
Middle Athabasca River
Meadow Creek
Miette River
Middle and upper Bow River
Healy Creek
Pipestone River
Siffleur River

The following watersheds have no records of porcupine activity:

Upper Athabasca River
Isaac Creek
Rocky River
Southesk River
Middle and upper Cascade River
Fortymile Creek
Spray River

The American porcupine is most common in Main Range valleys that have extensive Engelmann spruce-subalpine fir forests although the number of areas with no porcupine

Figure 3.35. Distribution of porcupine and wolverine observations in Banff.

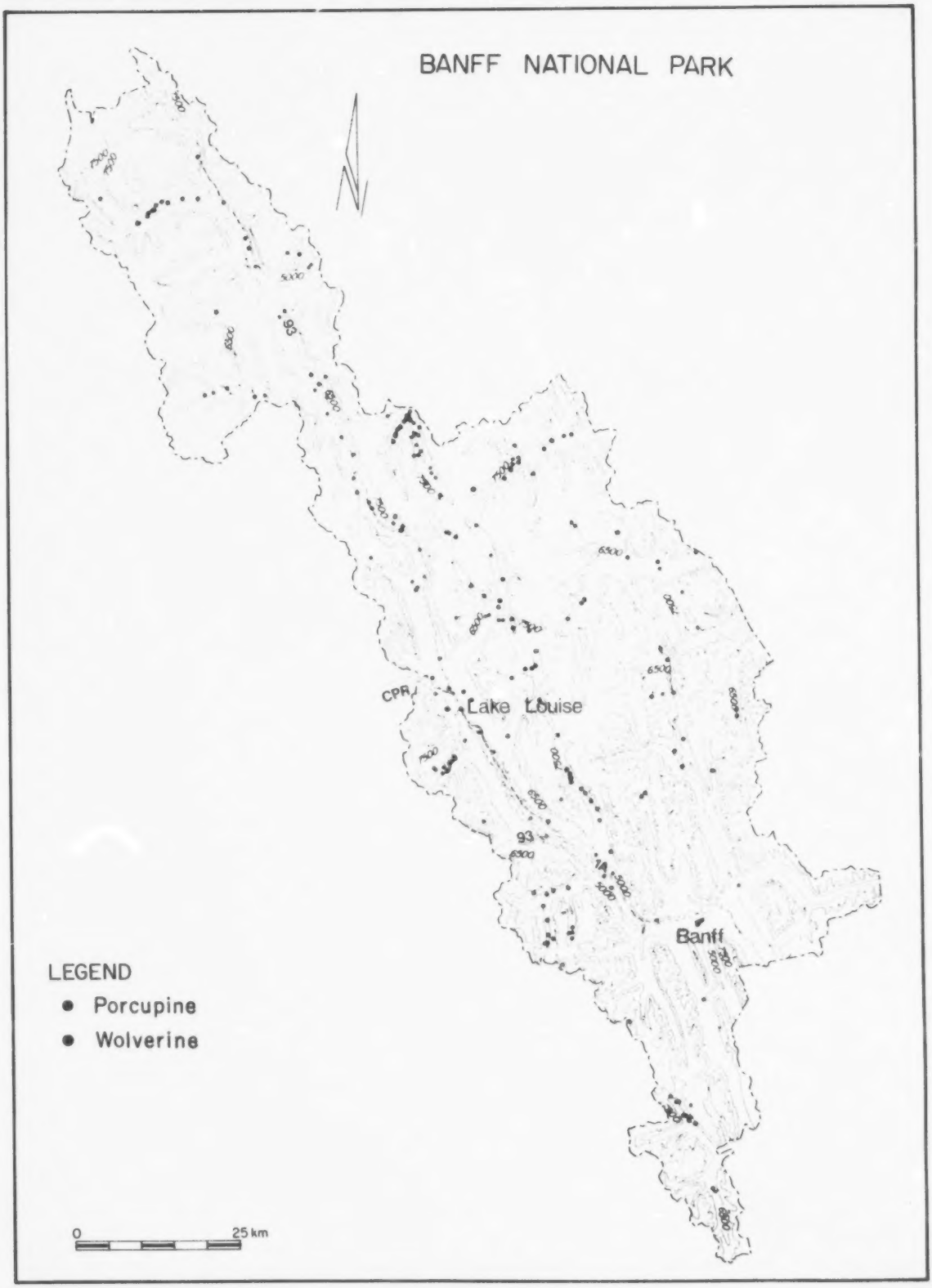
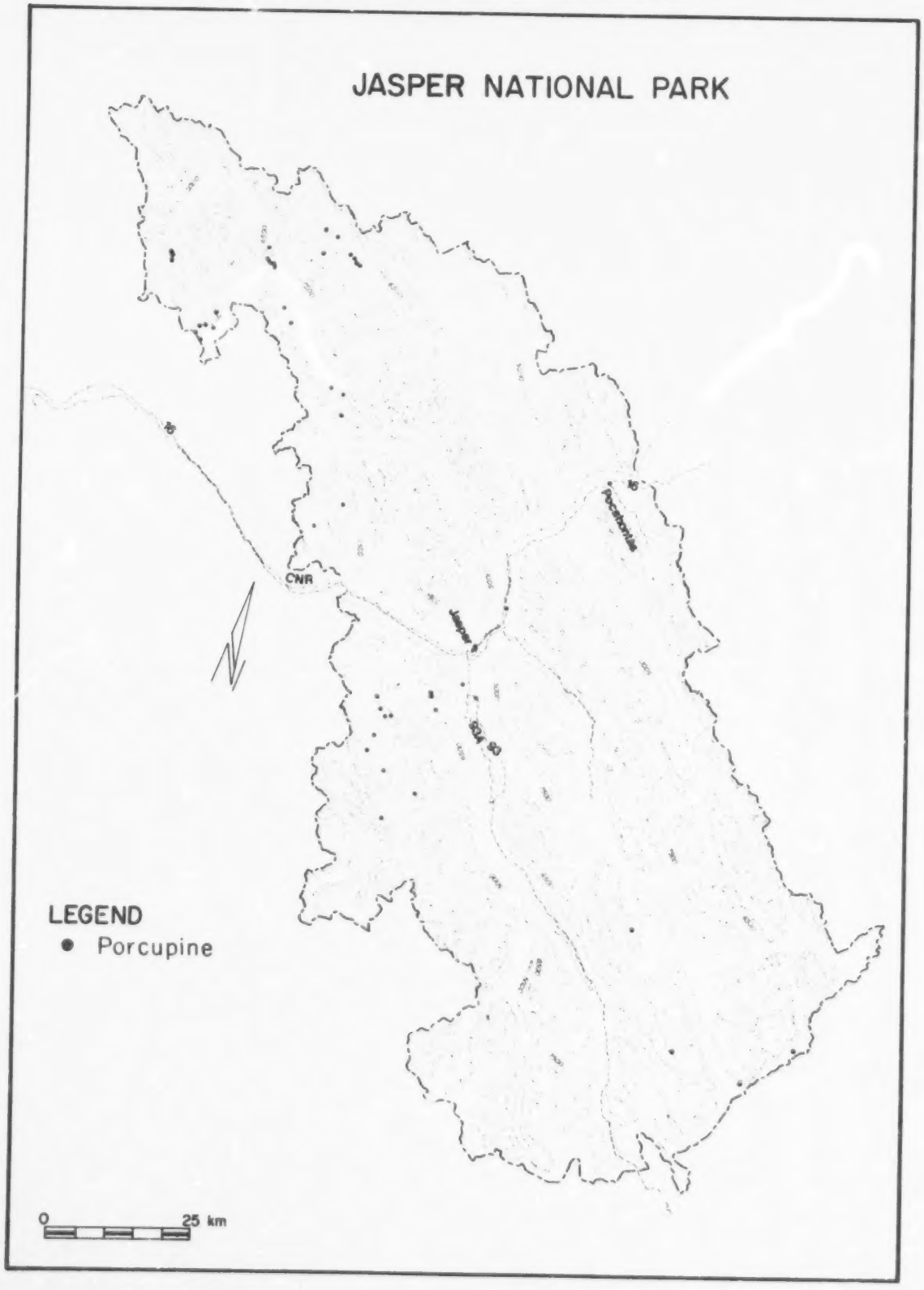


Figure 3.36. Distribution of porcupine observations in Jasper.



observations may be as much a factor of this animal's slow movements and nocturnal activity as of variability in densities between watersheds. The Smoky River and upper Snake Indian River have markedly higher American porcupine populations than other Banff and Jasper watersheds.

HABITAT

Porcupine are found from the montane to the alpine. In winter, 44% of porcupine observations were in the lower subalpine and a further 44% in the upper subalpine, 8% in the montane and 4% in the alpine. The most important ecosites sampled are all upper and lower subalpine and are derived from till or fluvial material on moderately well-drained sites. The most important vegetation types include lodgepole pine and lodgepole pine-spruce forests, open and closed Engelmann spruce-subalpine fir forests and open subalpine larch/heath forest forest. Although throughout their range porcupines occur in both deciduous and coniferous forests, in the mountain parks porcupines have not been found in aspen or poplar stands.

LIFE HISTORY

The porcupine is primarily nocturnal and is active all winter. It leads a solitary life except during the October to December breeding season (Smith 1977). Young are born between May and August. Usually a single young is born but infrequently twins are born. Porcupines mature at about 2.5 years and live 10 years or longer (Brander 1971).

Cougars, wolverines and fisher have some success preying on porcupines (Smith 1977). Wolves, coyotes and foxes also take porcupines but are more often injured in the attempt to make a kill. Young are most vulnerable to predation just after birth.

The summer diet of porcupines includes green leaves of forbs, shrubs and trees. Favored summer foods are aspen and white birch leaves, although in Banff and Jasper porcupines occur most commonly in habitats where these are not available. In winter, porcupines feed on the cambium and inner bark of trees and on new twigs and buds. Larch, subalpine fir and white spruce are used in winter in Banff and Jasper, and lodgepole pine is used extensively in the Smoky River valley. A winter study in New Brunswick revealed that porcupines feed on tree species in proportion to their occurrence (Speer and Dilworth 1978). Porcupines also gnaw on bones and antlers.

MANAGEMENT CONSIDERATIONS

In a national park, there are no valid reasons for the persecution of this species to continue. Porcupines should be discouraged from damaging buildings not by killing the animals but by proper construction practices such as using substitutes for plywood on exposed surfaces. Existing buildings may be partially protected with tin or fiberglass. Killing of troublesome porcupines is unacceptable because of their very low reproductive rates and their importance as the only major large prey for over-wintering carnivores such as wolverines in deep snow areas.

Foresters generally look on porcupines unfavorably since porcupines may kill trees by girdling bark or cause irregular growth by clipping terminal buds. This attitude toward porcupines does not apply in a national park and these activities can be beneficial when the effect is to thin even-aged stands of trees.

COYOTE *Canis latrans*

COYO

STATUS AND DISTRIBUTION

The coyote occurs throughout southern and northwestern Canada, being most common in the northwest (Banfield 1974). It has steadily expanded its range northward and eastward in the last century to include the northern Yukon, central and southern Ontario and Western Quebec.

Coyotes are found throughout Alberta, from short grass prairie to boreal forest and alpine tundra (Soper 1964). Two subspecies of coyote are present in the Rocky Mountain of Alberta and British Columbia. The mountain coyote (*C.l. lestes*) ranges through the Rockies from approximately the Columbia Icefields area south into the United States. The northwestern coyote (*C.l. lincolatus*) is found throughout northern Alberta including the northern Rocky Mountains. In Waterton Lakes National Park the coyote is "fairly well-represented" (Nielsen 1973). An inventory of Kananaskis Provincial Park revealed the coyote to be widespread and moderately abundant (Salt 1977). Coyotes are common in low elevation valleys in Yoho National Park where 230 coyote observations were made between 1970 and 1976 (McCrory and Blood 1978). It is also a common species in Kootenay National Park where wardens reported 185 coyote observations during the same time period (Kootenay warden files).

Coyotes are abundant in both Banff and Jasper. They are restricted to the valley bottoms of the major river systems during winter. Their distribution is more widespread during the snow-free months, as they expand into watersheds that were unsuitable during winter because of deep snow.

A total of 820 coyote tracks were counted during 4658.5 km-day of winter tracking in Banff and Jasper. Based on these data, coyotes are more common in Banff (0.20 tracks/km-day) than in Jasper (0.13 tracks/km-day), although this may be biased somewhat by the greater amount of tracking done at lower elevations in Banff. Between 1976 and 1980, 686 and 372 additional random records of coyotes or their sign were recorded in Jasper and Banff respectively.

Main range watersheds receive very little coyote activity, particularly during winter. A density of 0.14 tracks/km-day was recorded in Main Range watersheds versus 0.18 tracks/km-day over the entire study area. Coyotes are very rare along the continental divide during winter. No coyote tracks were reported during 7525 km-day of winter track transects in the following Main Range watersheds in Banff: Bryant Creek, Howse River, and upper Spray River; and Jasper: Astoria River, Meadow Creek, upper Snake Indian River, Snaring River, Smoky River, and Whirlpool River. Scattered sightings occur in these watersheds during summer, with the exception of Smoky, upper Spray and Whirlpool, watersheds, in which no coyotes were recorded between 1976 and 1980 (Warden files, inventory files).

In Banff coyotes are commonest by far in the lower Bow River watershed (3.00 tracks/km-day). Other watersheds of importance to coyotes during winter are:

Lower Red Deer River (0.58)
Lower North Saskatchewan River (0.55)
Lower Cascade River (0.50)
Middle Cascade River (0.35)
Alexandra River (0.33)

Based on 260 coyote observations, the following watersheds are favoured by coyotes from May to October:

Middle Bow River (35)
Lower Athabasca River (31)
Lower Bow River (19)
Jasper townsite (19)
Lower Red Deer River (20)

Lower North Saskatchewan River (14)
Lower Cascade River (14)
Middle Athabasca River (14)

It should be noted that summer rankings are more subject to observer bias than winter. Track counts are based on unit effort (km-day) which is consistent through all watersheds, while summer ranks are based on sightings which are prejudiced by the amount of time spent in each watershed. Thus, coyotes will be over-represented in valleys with roadways transecting them.

In Jasper, the townsite area had highest track count densities (1.21 tracks/km-day). High densities were also recorded in the following watersheds:

Lower Athabasca River (0.71)
Sunwapta River (0.67)
Middle Snake Indian River (0.42)
Middle Athabasca River (0.41)
Cairn River (0.28)

. Random sightings of Coyotes and their sign (Warden files, inventory files) indicate that the lower Maligne River valley is also important to Coyotes.

HABITAT

Coyotes in Banff and Jasper are most abundant in montane valley bottoms, especially during winter. Of 820 coyote tracks recorded during winter tracking transects, 86% were in the montane, 11% in the lower subalpine, and 30% in the upper subalpine. 512 km-day of winter tracking in the alpine ecoregion yielded no coyote tracks. There are no sight records of coyotes in the alpine ecoregion during the winters of 1975 to 1980. Nine of the 10 most important ecosites for coyotes are montane.

Deep snow, which inhibits both feeding and travel, is probably the main factor confining coyote use to lower elevations. Coyotes are most common at snow depths ranging from 1 to 20 cm in Banff and Jasper. Tracks were not recorded in areas having more than 60 cm. of snow. Furthermore, concentrations of ungulate species in the lower valleys during winter provide coyotes with an abundant carrion supply from motor vehicle, predator and winter kills. Coyotes in Yoho (McCrory and Blood 1978) and Waterton Lakes National Parks (Nielsen 1973) also display a marked preference for low elevation habitats during winter.

As spring arrives and snow pack diminishes at higher elevations, some coyotes may extend their foraging into alpine areas, but most still remain at lower elevations. Of 260 random summer sightings of coyotes (Inventory files) 109 (42%) occurred in the montane, 44% and 12% were in the lower and upper subalpine ecoregions respectively, and only 6 of the 260 sight records were from alpine areas, indicating that their use of alpine areas is probably minimal even during the summer.

Elevational range of coyotes in Banff and Jasper is 1080 to about 2630 meters.

Ecosite importance rankings in the wildlife legend (Map Supplement) were calculated by two different methods for winter and summer. Winter ranking is based on winter track densities (ie. the number of tracks/10km-day.). A weighted ranking system based on available prey species is used for summer (see Methods above). The latter method is similar to that described for cougar, but uses data from Bowen (1978) to rank the relative importance of prey species in the coyotes summer diet. His data are from 1967 coyote scats collected over three summers in the lower Athabasca River valley. Coyote diet in that area is probably reasonably representative of coyote diet in Banff and Jasper as a whole.

Soper (1970) indicated the wide range of habitats frequented by coyotes in Jasper when he wrote "Environmental features are mixed wood forest, lowland meadows, grassy benches, and woodland glades". Winter track densities of coyotes in Banff and Jasper

are highest in the following montane vegetation types (in decreasing order of importance):

white spruce/prickly rose/horsetail (C4) forest
aspen-white spruce forest
aspen/hairy wild rye-peavine (C16) forest
Douglas fir/hairy wild rye (C1) forest
creeping juniper-northern wheatgrass-sedge (L6) meadow
montane shrub meadow(S1 and S3)

Oertli and Stelfox (1975) found similar results in the Bow River valley where coyotes preferred open grassland alluvial fans and mixed coniferous or well drained aspen cover on gravelly terraces above floodplains.

Sedge meadows, as wetland inclusions in forests and along braided stream channels, are used heavily by coyotes in the lower subalpine ecoregion, where they support high densities of small rodents and allow easy travel. Open spruce-fir/willow/hairy wildrye (O18) and spruce/Labrador tea/brown moss (O11) forests are of moderate importance to coyotes. Homogeneous lodgepole pine and lodgepole pine-spruce stands, which occupy a large part of the lower subalpine ecoregion receive little use by coyotes.

Shrubby meadows are the most important vegetation type in the upper subalpine, although they are of only moderate importance compared to lower elevation vegetation types. Coyotes are rare in closed Engelmann spruce-subalpine fir forests, which cover much of the upper subalpine.

All coyote dens recorded in Banff and Jasper were in the montane and lower subalpine (Warden files; Inventory files; Bowen 1978). Habitat descriptions were recorded for 18 of these dens. Favoured denning habitat is well-drained, south-facing grassy slopes and open to semi-closed forests with greater than 50% deciduous canopy. Dens were located on flatland (11) or on slopes of southerly aspect (7). Fluvial (11) or glacial till (5) deposits appear to be preferred.

LIFE HISTORY

Coyotes in Banff and Jasper subsist on a wide range of food items. Small to medium-sized mammals provide coyotes with a consistent, year-round food source. Ungulates are consumed mostly as carrion. However, in winter especially, coyotes will prey upon deer, sheep and even small elk (one report).

Bowen (1978) studied the social structure and foraging ecology of coyotes in the lower Athabasca River valley between 1974 and 1977. He found the Meadow vole to be the major prey species of coyotes. Small mammals are eaten most heavily in mid-winter and early spring. Columbian ground squirrels are the major summer food item. Similarly, of 42 observations of coyotes with food, other than ungulates, in Banff and Jasper between 1945 and 1980 (Warden files, inventory files) ground squirrels (sp.) (11) and small rodents (11) were the dominant prey. Others included beaver (5), mink (3), Varying hare (2), ducks (2), domestic dog (2), Spruce Grouse (1), Blue Grouse (1), ptarmigan (sp.) (1), marten (1), Canada Goose (1) and duck (sp.) (1). Ground squirrels and mice appear to be of similar importance to coyotes in Yoho National Park. Of 35 coyote feeding observations there, 11 involved small rodents and 9 Columbian ground squirrels (McCrory and Blood 1978).

Bowen found that coyotes in the lower Athabasca River valley relied heavily on ungulates, especially during the winter. It is impossible to separate carrion from prey, using scat samples, however he did document eight instances of ungulate predation by coyote during his study: six mule deer and two bighorn sheep. In Banff and Jasper, from 1945 to 1976, a total of 41 (31 successful, 10 attempted) instances of coyote predation on ungulates were recorded (Warden files, Inventory files) (Table 3.1). Mule deer and to a lesser extent bighorn sheep are the principal prey species. Successful predation on larger ungulates such as moose and elk is very rare. The single elk and one of the two moose

Table 3.1 Coyote ungulate prey (as recorded on Banff and Jasper park wildlife cards, 1945 to 1976).

Park	Species	SUMMER M	F	YOY	YLYUNK	Total	WINTER M	F	YOY	YLYUNK	Total	Year-round total
BANFF	Mule deer	0	(1)	0	2(1)	0 **2(2)**	1	1	2	3	10 **12(2)**	
	Elk	0	0	0	0	0 **0**	0	0	0	0	0 **0**	0
	Moose	0	0	1	0	0 **1**	0	0	0	0	1(1) **1(1)**	2(1)
	Bighorn sheep	0	(1)	(1)	0	0 **(2)**	0	0	0	0	0 **0**	(2)
	Mountain goat	0	0	(1)	0	0 **(1)**	0	0	0	0	0 **0**	(1)
JASPER	Mule deer	0	0	0	0	0 **0**	0	2(1)	0	2(1)	6(1) **10(3)**	10(3)
	Elk	0	0	0	0	0 **0**	0	0	1	0	0 **1**	1
	Moose	0	0	0	0	(1) **(1)**	0	0	0	0	0 **0**	(1)
	Bighorn sheep	0	0	0	0	0 **0**	4	1	0	1	(1) **6(1)**	6(1)
	Mountain goat	0	0	0	0	0 **0**	0	0	0	0	(1) **(1)**	(1)

( ) = unsuccessful attempts.

killed by coyotes were young of the year. Male mule deer and bighorn sheep seem relatively immune to predation by coyotes. Coyotes have been observed chasing bighorn sheep nursery groups three times by park wardens since 1945, and Shank (1976) observed 2 apparently successful and 5 unsuccessful attacks by coyotes on sheep on the Palliser Range in a single winter. Lambs were the apparent victims on both occasions. Coyote predation on Bighorn sheep is evidently more common than usually thought. Bowen noted an upswing in the frequency of occurrence of young cervids in coyote scats collected during June and early July, suggesting that coyotes may selectively prey upon newly-born deer and elk.

More than 75% of instances of predation and attempted predation on mule deer occurred during winter. Similarly, 60% of reports of predation on bighorn sheep occurred in winter. Sheep and mule deer are not well adapted to deep snow and are probably particularly susceptible to coyotes during winters of heavy snowfall.

Coyotes feed extensively on carrion and garbage (Nellis and Keith 1976, Bowen 1978; Berg and Chesness 1978). Ungulates are eaten mostly in the form of carrion. There are 47 reports of coyotes feeding on carrion in Banff and Jasper between 1945 and 1980 (park wildlife cards). Highway and train-killed ungulates may be major sources of carrion. Predator kills, winter kills, avalanches and drowning are among other sources. Elk are the most common source of carrion, probably because of the high number of this species killed by motor vehicles (Harrison et al. 1980).

Coyotes have a well-defined social structure. Bowen found that coyotes in the lower Athabasca River valley could be classified as transients, solitary residents, pairs or packs, and that a single coyote could ultimately fit into each category in its lifetime. He noted that coyotes tend to travel in packs more often in winter than summer. Bowen calculated mean home range sizes of male (14.2 km^2) and female (13.3 km^2) coyotes and found no significant differences during summer and winter. Adult males and females scent mark their home range at all times of the year. Marking is associated with the maintenance of territory (Bowen and Cowan 1980).

Only 6 observations of coyotes mating were recorded in Banff and Jasper between 1945 and 1981 (Warden files, Inventory files). They are 1 January, 7,9 and 10 February, and 3 and 19 March. Bowen (1978) found that coyote litters were born from 29 March to 10 June in the lower Athabasca River valley. Gestation period of the coyote is approximately 2 months (Banfield 1974). Thus, coyotes mate from early January to mid April in Banff and Jasper.

The mated pair seek out a den site as parturition approaches. In some years snow may still lie upon the ground. Average litter size from Warden records (1945 to 1976) in Banff and Jasper is 4.0 (3 to 6). Bowen (1978) examined the reproductive tracts of 4 female coyotes and found 7, 4, 5 and 6 placental scars (ave. 5.5). Nelles and Keith (1976) found an average of 6.0 scars per tract in central Alberta coyotes and an average post-partum litter size of 5.3.

Harrison et al. (1980) determined that a peak period of ungulate mortality in the Bow valley of Banff occurs in early May, when spring green-up draws ungulates to feed on roadside grasses. This source of carrion along the roadways is probably a major source of food for growing pups, and may provide inpetus for coyotes to den close to major highways.

There are 5 records of predation on coyotes in Banff and Jasper since 1945. Four of these incidents were by wolves (Warden files) while a cougar was reported to have killed a coyote near an elk carcass in the lower Athabasca River valley (Bowen 1978). Bowen feels coyotes are killed by wolves only rarely and that this is more often because of aggression than active predation. There is one record of an unsuccessful attempt at predation on a coyote by a wolverine (Banff warden files).

Other than during the breeding season, coyotes and dogs are "mortal enemies" (Gier 1975). There are no documented reports of dogs being killed by coyotes in Banff or Jasper; however, there are 5 reports of coyotes wounding and harassing dogs (Warden files 1945-1980). These occurred in June, July and November. Coyotes have been seen playing with dogs four times, three during the breeding season and once in July. Domestic dogs and coyotes are capable of breeding and producing hybrids, a high percentage of which are fertile (Gier 1975). Usually, the breeding season of hybrids is random, decreasing the chances of breeding with pure strain coyotes (Mengel 1971). Two of these coy-dogs were collected by Banff Park wardens in 1976 (Warden files) and one survived at least until 1978.

Sarcoptic mange occurs as a result of infection by a mite (*Sarcoptes scabei*), which burrows into the skin causing matting of fur, lesions, and in some cases hair loss (Gier et al. 1978; Bowen 1978). Mange has been reported sine 1952 in Banff and Jasper (Warden files). There is no evidence of periodic or cyclic outbreaks of this condition. Mange can cause mortality either directly or indirectly. Bowen found a coyote that had apparently died of hypothermia as a consequence of fur loss. Another mangy coyote had aparently been killed by another coyote. It was believed that the mange was a contributing factor to its death. In spite of these two reports, Bowen concluded that mange was not common in coyotes in the lower Athabasca River valley between 1974 and 1977. Only five of 43 coyotes he captured showed evidence of mange. McCrory and Blood (1978) reported 4 observations of mangy coyotes in Yoho National Park between 1970 and 1976.

MANAGEMENT CONSIDERATIONS

The coyote is an extremely adaptable species and in some cases actually thrives under human influence (Gier 1975). The status of the coyote is presently very secure in Banff and Jasper. It survived an intensive predator contol program in both parks during which coyotes were poisoned, trapped and shot on sight until the late 1940's and again during the rabies scare of the 1950's (section 1.3 above).

The most serious man-induced mortality now is from collisions with motor vehicles and trains. From 1964 to 1976 there were reports of 15 coyotes killed on highways in Banff National Park while in Jasper 12 were reported killed. Train-killed coyotes numbered 9 and 4 in Banff and Jasper respectively during the same time period. Injured animals that die away from the scene of the accident are not reported and since coyotes cause little or no damage to the vehicle hitting them, and are less obvious than ungulates, the frequency with with which this sort of mortality is reported is probably lower than for larger species. Removal of road and train-killed ungulates well away from roadside and railway right of ways will reduce the number of coyotes killed or injured while scavenging.

There are several reports of coyotes feeding on garbage at dumps or in developed areas. Coyotes suffering from mange are most likely to visit garbage dumps (Bill Samuel pers. comm.).

Coy-dogs are often larger and more vigorous predators than pure strain coyotes. They have become a serious problem to livestock owners in North America. To prevent these crosses from occurring, domestic dog control should be strictly enforced in Banff and Jasper townsites, especially from January until March when coyotes breed.

Coyotes were reported receiving food handouts from tourists along roadsides on 7 occasions between 1976 and 1980. This is a dangerous situation for both coyotes and humans.

TIMBER WOLF *Canis lupus* WOLF

STATUS AND DISTRIBUTION

At one time wolves occurred thoughout most of Canada with the exception of the Queen Charlotte Islands. They are now extirpated from much of southern British Columbia, the Prairie Provinces, Ontario, Quebec, the Maritime Provinces and Newfoundland (Banfield 1974).

Five subspecies of wolves have occurred historically in Alberta (Skeel and Carbyn 1977). The British Columbia wolf (*C.l. columbianus*) is found in Banff National Park, while in Jasper National Park this type intergrades with the northern timber wolf (*C.l. occidentalis*) which ranges through the northern half of Alberta.

Wolf numbers have fluctuated dramatically in the Rocky Mountains of Canada, primarily due to extermination efforts by ranchers and government predator control personnel. At present they are very rare in the south but become increasingly common farther north, especially in the Front Ranges of Banff and throughout Jasper. Wolves have increased in Jasper over the last 20 years (Carbyn 1974a) and are now common.

As early as 1859 wolves were being poisoned in the Athabasca valley by fur traders (Palliser 1860) and by 1896 they were considered uncommon, although some still ranged north of the Athabasca (Preble 1908). In seventeen years Lewis Swift killed only two at Henry House (Hollister 1911). Wolves were so rarely seen in Banff National Park in the early years of this century that the Chief Park Warden in 1945 had difficulty convincing his staff that wolves occurred there at all (National Archives, Ottawa).

Soper (1970) reported that wolves began to increase in Jasper around 1917 and 1918, and by 1942 they were well represented in the Park. Wolf numbers peaked in both parks in the 1940's, at the same time as ungulate populations peaked (Green 1948, Carbyn 1974a). Cowan (1947a) found the first wolf den in Banff, in an area near the Panther River where wolves still den today. Green (1948) estimated the 1947 Banff wolf population at 48, including two packs using the Bow valley.

Active predator control and rabies control programs led to a drastic decline in wolf numbers in Banff and Jasper in the 1950's. By the 1960's wolves were rarely seen in Banff (park wildlife cards). In Jasper, however, resident populations survived in most back-country watersheds after wolves had been largely eradicated from the Athabasca and Miette valleys.

In southern Alberta wolves have made a slight comeback but "are now of very rare and casual occurrence... " in Waterton Lakes National Park (Nielsen 1973). Several sightings in the Highwood River drainage since 1974 suggest that a resident pack may exist there (Mill and Anderson 1980). Wolves do not reside year round in either Yoho or Kootenay National Park, west of the continental divide. Between 1959 and1976 wolves or their sign were observed thirteen times in Yoho (McCrory and Blood 1978). One pack of 4 was reported and all other records were of pairs and lone individuals. One pair and 12 individuals were recorded by Kootenay park wardens between 1973 and 1977 (Kootenay warden cards).

In **Jasper National Park** 203 wolf tracks were observed during 46,585 km-day of winter tracking from 1976 to 1981. An additional 172 observations, including 23 sight records totalling 82 animals, were recorded. During the winter they are most abundant in the Athabasca River valley and the lower reaches of its major tributaries, although their wide-ranging hunting habits take them into many remote backcountry districts. Wolves were recorded in every watershed in Jasper during the winters of 1976 through 1980 (Warden files, inventory files). Watersheds of greatest importance to wolves during winter, based on winter track counts, random sightings and the presence of abundant wintering ungulate populations include: lower and middle Athabasca River, Miette River, lower Maligne River, Snake Indian River, Willow Creek and Moosehorn Creek.

Deep snow and scarcity of wintering ungulates limit wolf activity in the Main Ranges (0.55 tracks/10km-day). Wolves are more common in the Front Ranges during winter (1.35 tracks/10km-day), where shallower snow and more open vegetation result in a more diverse and abundant ungulate populations and are more suitable to a cursorial mode of hunting.

Even though wolves travel less extensively during summer while they are rearing pups (Mech 1970), summer distribution of wolves in Jasper is almost as widespread in winter. It is probable that Main Range watersheds are frequented more often by wolves during summer as ungulate ranges expand.

Wolves are presently increasing their numbers in Jasper National Park. The winter population of the lower Athabasca River valley has risen from an estimated 20 (Carbyn 1974b) in 1970 to nearly 30 (present study) in 1980.

Carbyn determined that five major wolf packs were present in Jasper during the winter of 1969-70. Each pack spent at least part of its time in provincial lands outside the park boundaries. Packs from the following areas were specified: Smoky River-Miette River, Willow Creek-Devona, Rocky Forks, Whirlpool River and Brazeau River - Sunwapta Pass. Packs of wolves have been reported by wardens and inventory staff in all of these areas since 1976. It appears that wolf pack home ranges have not changed significantly over the last five years. Wolves in the Willow Creek-Devona, Rocky Forks and Townsite area, at least, den within the park.

In **Banff National Park** wolves are approximately eight times less common than in Jasper. Only 43 wolf tracks were tallied during 2878.8 km-day of winter tracking. From 1976 to 1980, wolves were sighted six times in Banff, totalling 9 animals. In addition 46 observations of tracks and scats were reported (Warden files; inventory files).

Wolves are most common in the Front Ranges, particularly the Clearwater River, lower Red Deer River, Panther River and middle Cascade River watersheds; 78% of wolf sightings and 54% of wolf tracks recorded between 1976 and 1980 were from these four watersheds, which occupy about a quarter of Banff. Wolves in these areas

undoubtedly spend some of their time, particularly during winter, in provincial lands to the east where they have been subject to provincial predator control activities (Carbyn 1968; Brady and Wackerle 1971).

Wolf sightings in other areas of the park usually involve individuals or small groups. Other watersheds in Banff, besides the four aforementioned, in which wolves have been observed between 1976 and 1980 are the middle Bow River, lower Cascade River, upper Cascade River, Johnston Creek, Mistaya River, North Saskatchewan River, and lower Spray River. Wolves were resident in the middle Bow River valley of Banff in the late 1940's and early 1950's (Green 1951a). At present, wolves are only sporadic visitors to the Bow valley. There were only 2 sightings of single wolves, one track and one scat recorded from the Bow valley between 1976 and 1980. Wolves are very rare south of the Bow River in Banff; a single scat in the lower Spray River valley is the only suggestion of wolf occurrence in this area since 1974, when a single wolf was sighted at Mile 15 of the Spray fire road.

Only one pack is known to den in Banff. Pups were heard howling at a rendezvous site near the Panther River on 25 July 1980 (JLK, HFC). Carbyn (1974b) found that rendezvous sites averaged 2.3 mi (3.7 km) from the den site (1.1–5.1 mi; 1.8–8.2 km, N=6) in the Willow Creek area of Jasper. The Panther River observation was considerably farther from the park boundary than this. A den was reported by wardens in 1946 3.2 km from where the pups were heard howling in 1980.

Wolf packs of greater than five animals were not recorded in Banff between 1976 and 1980.

HABITAT

Habitat use by wolves is not easily defined or quantified because of their wide-ranging habits. In the course of a day wolves may travel through a number of ecosites and vegetation types. In Banff and Jasper wolf travel routes are often influenced by the presence of roads and trails which give ready access into areas that may not be used otherwise. Historically, wolves in the Northern Hemisphere have inhabited all major habitat types except tropical rain forests and arid deserts (Mech 1970). Banfield (1974) wrote that "Wolves show little preference for special habitats..." and noted that they occur on the arctic tundra, mountain tops, the plains and in coniferous and eastern deciduous forests.

Probably the major influence on wolf habitat use in any particular area is the habitat use of its primary ungulate prey species. To determine the relative importance of ecosites to wolves in Banff and Jasper, ecosites were ranked using a weighted ranking system that takes into account the habitat use of favoured wolf prey in Banff and Jasper (see Methods above).

Of the 12 most important ecosites to wolves during winter using the above system, 11 are montane. This is a reflection of the concentration of ungulates, especially mule deer and elk, at lower elevations during the winter. Winter tracking data also reveals that wolves are by far most abundant in the montane ecoregion (.23 tracks/10km-day). Wolf tracks were about 6 and 60 times more common in the montane than in the lower subalpine and upper subalpine, respectively. No wolf tracks were seen in the alpine during winter. Carbyn (1974b) noted that on numerous occasions wolves crossed mountain ranges from one watershed to another in the Willow Creek area of Jasper. Wolves are not equipped for travel in deep snow and consequently use game trails, roads, or other packed travelways where available.

Den and rendezvous sites are two forms of localized but highly important habitats used by wolves during spring and summer. Carbyn (1974b) located and examined four different wolf dens in the Willow Creek area of Jasper. He found that all dens were in the lower subalpine ecoregion at similar elevations (1400 meters). Carbyn also reported that wolves formerly denned near Disaster Point, at Dominion Prairie, along the Athabasca

River near the Maligne horse range and in the Buffalo Prairie area. These are all in the montane ecoregion in closer association with human facilities than dens in the Willow Creek area. Although Carbyn felt wolves were excluded by human activity from the lower Athabasca River area, it is evident that they are again denning in the montane. Six young wolf pups were reported in the Devona area in 1978 (D. Wilkinson, Jasper Warden Service, pers. comm.), and wolves with young rendezvoused between the Jasper warden office and Fifth Bridge in the summer of 1980. Wolves were present during the denning season on the Dominion Prairie in 1980 (T. Damm, Jasper warden service, pers.comm.). It is possible that wolves are again denning at areas described by Carbyn. All dens located by Carbyn (1974b) were in well-drained areas, and he felt that site selection is based primarily on drainage and the nature of the soil.

Rendezvous sites are occupied in June and July and are usually in open bogs or grasslands (Mech 1970). In the Willow Creek area rendezvous sites are characterized by varied topography, diversity of vegetation, and open meadows in which mule deer are commonly seen (Carbyn 1974b). These "pup activity areas" are usually located within 3.5 km of the den site; thus, open shrublands or grasslands in the vicinity of known den sites should be regarded as at least potentially important summer habitat for wolves. Rendezvous sites are not restricted to open meadows. Carbyn found one in a dense, mature Engelmann spruce forest which he thought was used because of heavy rainfalls.

LIFE HISTORY

With its large size, pack-hunting strategy and ability to digest large quantities of food in a short time, the wolf is well adapted to prey upon large mammals (Mech 1970). Ungulates are the primary prey species in most areas of North America. The species of ungulates on which wolves prey most heavily vary according to geographic location and availability. Barren ground caribou provide the bulk of food for arctic wolves (Kuyt 1972; Parker 1973); the white tailed deer in the Great Lake region (Mech and Frenzel 1971; Kolenosky 1972); and moose on Isle Royale (Mech 1970) and some portions of Alaska. Smaller prey such as beaver, hares, and small mammals are also eaten, especially during the summer, but the energy expended per pound of meat obtained is probably greater than when hunting large animals (Mech 1970).

In Banff and Jasper, the ungulate prey base available to wolves is diverse (Cowan 1947a; Carbyn 1974b). Seven different species of ungulate occur in both parks. Park studies by the two investigators cited above, and by H. Green (1951a), along with 35 years of random observations (Warden files, inventory files), provide a good knowledge of wolf predator-prey interactions in Banff and Jasper.

Carbyn found that elk calves and mule deer are preferred prey in the Willow Creek area of north eastern Jasper. The preferred prey species of wolves undoubtedly vary within Banff and Jasper depending on the area involved. Cowan reported that elk occurred most frequently in wolf scats in Jasper National Park as a whole, which includes such areas as the upper Athabasca River, Miette River and Whirlpool River where mule deer are not common and elk are more susceptible to predation because of deeper snow. Mech (1970) wrote that "... if two or more species of large prey inhabit the same region, wolves apparently concentrate on the smallest or easiest to catch". Green (1950a) considered elk to be the dominant prey species of the wolf in Banff National Park at a time when the elk population in the park was about four times larger than the combined population of moose, mule deer and bighorn sheep.

It is interesting to note the high percentage of moose killed by wolves in Jasper (Table 3.2), especially since moose populations are lower than elk. In areas of high to moderate deer concentration, moose were not often attacked by wolves during winter. Since moose are more dispersed than other ungulates, there is a greater potential for wolf/moose encounters, which may account for the relatively high number of wolf-killed moose found in Jasper as a whole. Most of the moose killed by wolves in Banff were in the Bow River valley in the 1940's and 50's.

Table 3.2. Wolf predation on ungulates (as recorded on Banff and Jasper warden wildlife cards, 1945 to 1976).

Park	Species	SUMMER M	F	YOY	YLY	UNK	Total	WINTER M	F	YOY	YLY	UNK	Total	Year-round total
BANFF	Mule deer	0	0	0	0	1	**1**	2	1	0	0	1	**4**	5
	Elk	0	(1)	2(1)	0	(1)	**2(3)**	3	1	1	2	7(2)	**14(2)**	16(5)
	Moose	1	0	1	1	0	**3**	1	2(1)	1	0	4	**8(1)**	11(1)
	Bighorn sheep	0	1	0	0	0	**1**	0	0	0	0	0(2)	**0(2)**	1(2)
	Mountain goat	0	0	0	0	0	**0**	0	0	0	0	1	**1**	1
JASPER	Mule deer	(1)	1	0	0	1(1)	**2(2)**	4	6	0	1	3	**14**	16(2)
	Elk	2	4(1)	4	1	1(4)	**12(5)**	7(1)	9	4	1	3(4)	**24(5)**	36(10)
	Moose	2(1)	5	3	4	4	**18(1)**	8(1)	0	0	2	4(1)	**14(2)**	32(3)
	Caribou	0	0	0	0	1	**1**	1	1	0	0	1(1)	**3(1)**	4(1)
	Bighorn sheep	0	1	0	0	0	**1**	0	7(1)	0	3	1(1)	**11(2)**	12(2)

( ) = unsuccessful attempts.

Both Cowan (1947a) and Carbyn (1974b) found bighorn sheep to be of low importance to wolves in Jasper. According to warden reports since 1945, sheep are preyed upon to a greater extent in Jasper than Banff (Table 3.2) but are nonetheless a minor prey species relative to elk, deer and moose. Sheep usually feed in close proximity to rocky escape terrain which makes them less vulnerable to predation by wolves (Carbyn 1974b), and are most vulnerable to wolf predation when crossing valleys or grazing in areas remote from escape terrain (Cowan 1947a). Cowan noted that wolves in the Buffalo Prairie/Old Fort Point area regularly surprised sheep away from escape terrain such that the population "was kept to a point of bare survival". Sheep on Cinquefoil Ridge near Talbot Lake vacated their wintering area during the winter of 1979, when a pack of wolves intensively hunted the area, killing at least two sheep (Van Tighem et al. 1980). This area does not have extensive escape terrain.

Goat and caribou are very seldom preyed upon by wolves in Banff or Jasper. Caribou are very rare in Banff and uncommon in Jasper, and winter in deep snow areas seldom visited by wolves. Goats inhabit areas that are usually inaccessible to wolves. Most wolf predation on goats is when goats are visiting mineral licks during summer or crossing snowbound valleys during winter (Cowan 1947a).

Non-ungulate prey species are of minor importance to wolves in Banff and Jasper. Smaller mammals up to the size of beaver occurred in only 2% of winter scats and 3% of summer scats of wolves in the Willow Creek area of Jasper. Cowan found small mammal remains in 18% of wolf scats collected throughout Banff and Jasper from 1943-1946. Seven percent of these remains were beaver which were more abundant then than now (Carbyn 1974b). Cowan found beaver remains in 25 of 60 pup scats at a den near Buffalo Prairie. Beaver have been referred to as a buffer or alternate prey species by investigators in Algonquin Park, where wolves were able to maintain stable populations during a decline in deer numbers by feeding more heavily on beaver (Voigt et al. 1976).

Other non-ungulate prey species that have been reported in the diet of the wolf in Banff and Jasper are small rodents, Columbian ground squirrels and Ptarmigans. It is likely

that various other species are also taken by wolves opportunistically. Mech (1970) remarked that "Probably every kind of backboned animal that lives in the range of the wolf has been eaten by the wolf. Remains of mice, mink, muskrats, squirrels, rabbits, and various birds, fish, lizards, and snakes are often found in wolf droppings".

Wolves have a hierarchical social structure that enables them to travel and hunt in packs (Mech 1970). Individuals or small groups of wolves may temporarily stray from the pack during extended hunts. Lone wolves are usually old or socially subordinate individuals that have lost acceptance as members of packs. Average group sizes of wolves in Banff and Jasper are 1.9 and 3.2 respectively (Table 3.3). A pack of 25 wolves in the Smoky watershed of Jasper is the largest pack recorded in Jasper. The largest pack seen in Banff since records have been kept, numbered 14.

Pelt color is highly variable in the wolf. In Banff and Jasper black, gray, tan, red-brown, silver-black, and cream-white wolves have been reported. Black wolves are most common in both Banff and Jasper with gray wolves second. Pure black wolves are slightly more prevalent in Banff (72%) than Jasper (63%). The pure white color phase seems to be restricted to Jasper while brown or tawny wolves are more common in Banff than Jasper. Cowan (1947a) reported 55% black and 45% grey wolves (N=80) from Banff and Jasper in the mid '40's.

Wolves mate during late winter. Trampling and blood spots in the snow and increased scent post marking are signs of wolf mating activity. Carbyn (1974b) used these criteria to conclude that wolves in the Willow Creek area of Jasper mate from 8 February to 21 March. Green (1950) noted that wolves in Banff National Park mate from the end of February until early March.

Pregnant wolves seek out a suitable den site as early as four to five weeks before the pups are born (Mech 1966). Carbyn (1974b) found first signs of activity at a den site as early as 30 April in northeastern Jasper. The female may dig a new den or she may re-use an existing one. Of 14 dens described in Banff and Jasper, 10 were dug into soil, usually in a sandy knoll or sidehill; two were in crevices between boulders; and one was dug into an old beaver lodge (Cowan 1947a; Green 1950; Carbyn 1974b). Old ground squirrel or badger dens may be enlarged and used for dens.

Gestation period is between 60 and 63 days, which would place the birth dates of pups between 12 April and 11 May in Jasper, based on Carbyn's (1974b) determination of mating period. Average litter size of wolves in Banff from 7 warden observations of females with pups is 4.7 (range=3-9); in the Willow Creek area of Jasper Carbyn reported a similar average of 4.4 pups (N=5, range=3 to 6). Adult pack members use the den site as a focal point for their hunting forays and all pack members help feed the female and young (Mech 1970). In the Willow Creek area wolf packs left the dens in mid-June to establish rendezvous sites described above.

There are conflicting opinions as to whether wolves generally travel along well-defined circuitous routes during winter (Mech 1970). This no doubt varies, depending on snow conditions, topography and the density and locations of prey species. In the mountains, wolves may be more likely to travel along certain routes because of the confining effect of mountain ranges. Carbyn (1974b) noted that a wolf pack in Jasper travelled in a definite circuitous north-south pattern using the Snake Indian River and Moosehorn Creek valleys. Wolves which winter in areas of deep snow accumulation in Jasper such as the Whirlpool, upper Athabasca and Southesk River valleys travel extensively along frozen river channels and use snowmobile and ski trails where available.

Mange is the commonest disease affecting wolves in Banff and Jasper National Parks. Caused by a mite (*Sarcoptes scabei*) it is characterized by crusted lesions on the skin and loss of hair (Todd et al. 1981). Historically, mange appears to have been commoner in Banff than Jasper. There are 9 reports of mange in wolves from Banff; 5 reported in 1946, and 1 each in 1947, 48, 51 and 74. A serious outbreak of mange occurred in the Bow and Cascade valleys from 1946 to 1948 (Green 1950). At least

Table 3.3. Numbers of observations of wolves in groups of various sizes in Banff and Jasper.

			Group size																
Park		# obs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	25
BANFF	#	**187**	90	33	22	13	9	7	3	0	4	0	4	1	0	1	0	0	0	0
	%		48	18	12	7	5	4	2	–	2	–	2	1	–	1	–	–	–	–
JASPER	#	**815**	342	124	83	79	50	40	25	15	13	10	19	7	1	5	1	0	0	1
	%		42	15	10	10	6	5	3	2	2	1	2	1	–	1	–	–	–	–

three wolves were found in extremely poor condition; badly dehaired and emaciated. Cowan (1947a) also mentions two mangy wolves that were shot by wardens in Jasper in 1945 and 1946, and another sighting of a mangy wolf in 1945. The next reported mangy wolf in Jasper was in 1971. There were no reports of mange in 533 wolves observed in Banff and Jasper between 1975 and 1980.

There are four records of wolves killing coyotes in Banff and Jasper from 1954 to 1980 (Cowan 1947a; Green 1950; Bowen 1978; warden files). All were considered to be interspecific aggression rather than predation. A dead wolverine was found near a dead elk on the Panther River valley in 1980. The area surrounding the kills was covered with wolf tracks and it was assumed that wolves killed both animals (KAM). The inner organs of the wolverine were eaten. There are three records of grizzly sows chasing a wolf or wolves away from a carcass in the Cascade valley in Banff. On two occasions pairs of wolves were seen waiting near ungulate carcasses being fed on by grizzly bears. Four wolves were seen chasing a grizzly at Mile 43 of the Icefields Parkway in the autumn of 1972 (Warden files). Carbyn (1974b) found the remains of a wolf near an abandoned den in the Willow Creek areas of Jasper. He believed that a bear may have killed it. This is undoubtedly a rare occurrence, but it is further evidence that the relationship between wolves and bears is a complex one. There are two records of dogs being killed by wolves in Jasper (Warden files).

MANAGEMENT HISTORY

Of all the Noth American mammals, the wolf has had the longest and most controversial history of conflict with and management by man. In the 1860's wolvese were subjected to massive poisoning campaigns on the Alberta prairies. Brown (in Carbyn 1974b) reported that 1000 wolves were killed in one winter at this time and Palliser (1860) described the use of strychnine in the Athabasca valley to poison wolves. The competition between wolves and humans for ungulate prey has been the subject of emotional debate for more than a century and shows no sign of abating. Certainly the wolf has more friends now than it did 100 years ago, but the poisoning continues, at least outside the parks.

As detailed above, wolves had been exterminated from the accessible parts of Banff and Jasper by the beginning of the twentieth century. Predator control records from 1924 to 1932 (National Archives, Ottawa) indicate that no wolves were killed in Banff during this period. Comparable records are not available for Jasper, but two wolves were shot in 1938 and several dens dug up during the ensuing years (Jasper park files).

Wolves increased dramatically in the 1940's coincident with a peak in ungulate population. Wolf control by rifle, cyanide gun and - in 1953 strychnine, caused a pronounced decline in wolf numbers during the 1950's. In 1953 alone, for example, 36 wolves were killed in Jasper, 5 in Banff, and 30 on provincial land adjoining Banff (Carbyn 1972b, Green 1955).

New understanding of wolf-prey relationships, changing public attitudes toward park management, and awareness that population control of elk and wolves might best be left to each other, led to ecological investigations of wolves by Lu Carbyn of the Canadian Wildlife Service in the early 1970's. His studies greatly improved knowledge of Rocky Mountain wolves and added strength to Parks Canada's new committment to predator protection (Carbyn 1972 1974a 1974b 1976, Skeel and Carbyn 1977).

MANAGEMENT CONSIDERATIONS

Pimlott (1967) wrote that once "... trapping and hunting is discontinued wolves adapt to the presence of people". This appears to be true, at least in Jasper National Park, where wolf populations are flourishing and wolves becoming increasingly common, even denning in close association with man and his facilities. Pimlott also stressed the fascination that wolves have for humans as shown by the thousands of people who visit Algonquin Park and the Superior National Forest to see wild wolves or hear them howl, and said that "If wolf listening became popular as a natural experience the image of the wolf would undergo a rapid transformation". In light of the increasing number of wolves in Jasper and the heightened chance of witnessing their lives, "... Imaginative and well-executed interpretive programmes... " (Carbyn 1974b) could make use of this resource in order to increase support for it.

Human disturbance of den and rendezvous sites should be minimized, however; interpretation of free-ranging wolves should be limited to autumn, winter and spring, and locations of denning areas should not be divulged to photographers. Carbyn (1974b) outlines four instances when wolves left den sites after they had been either directly disturbed by humans or accidentally appraoched within 150 - 200 meters. Wolves are most vulnerable to human disturbance from about 15 April to 21 June which corresponds to denning and rendezvous periods.

There have been several reports of wolves being killed on the highways and railway in Jasper between 1975 and 1980. Although this is not a major source of mortality at present it could become more significant as traffic volume increases. Ungulates that are killed by automobile and trains should be removed from the vicinity of the roadside or tracks to lessen the chance of wolves being killed while feeding on these carcasses. Construction activity near known or suspected den and rendezvous sites while wolves are using them may cause wolves to abandon them.

Wolves in both Banff and Jasper are not wholly confined within park boundaries (Carbyn 1974b, Brady and Wackerle 1971) and as a result are subject to predator control on provincial lands. The extent to which park wolf populations are ultimately influenced by predator control is not well understood, but it is probable that the great disparity in wolf populations between Banff and Jasper is a result of historically more intensive wolf control on lands adjacent Banff, compounded by the more limited extent of ungulate winter range in Banff. Monitoring of provincial wolf-control activities would help to determine the magnitude of their impacts on park wolves. Carbyn (1972b) recommends establishment of a buffer ecoregion adjacent to Banff and Jasper where wolves would be protected by provincial statute.

As top-level carnivores, wolves are essential members of Banff and Jasper's fauna. Being natural regulators of ungulate populations, wolves provide a buffer against severe ungulate overpopulation. Some of the problems associated with ungulate over-population (for example, elk in the 1950's) are elimination of fragile plant species, erosion of slopes because of vegetation loss, increased competition among ungulate species, increase of unpalatable vegetation, and disease and poor vigour which may lead to crash declines

(Carbyn 1974a). Just as "... a deer herd lives in mortal fear of its wolves, so does a mountain live in mortal fear of its deer" (Leopold 1949). Wolves are believed to cull out prey animals that are least healthy or vigorous, thus improving the overall genetic health of prey populations and improving their long term survival (Mech 1970).

The interactions of wolves and their prey remain largely unhindered by human interference in much of Banff and Jasper, and are thus valuable as subjects of scientific interest.

RED FOX *Vulpes velox* **REFO**

STATUS AND DISTRIBUTION

The red fox's adaptability is reflected by its wide range in Canada. It is present in all parts of Canada, being scarce only on the west coast of British Columbia, the southern plains of Alberta and the high north (Banfield 1974).

Soper (1964) recognizes two subspecies of red fox in Alberta; the British Columbia red fox (*V.v.abietorum*) and the northern plains (*V.v. regalis*). The former variety is found throughout the boreal forest of northern Alberta an the northern Rocky Mountains including Jasper National Park. The northern plains subspecies occurs in east-central and southeastern Alberta and west into the aspen parklands. Red foxes in the southern Rocky Mountains and foothills including Banff National Park have not been identified to subspecies.

Red foxes are generally rare and sparsely distributed in the Rocky Mountains. Soper (1967) considered the red fox rare in Waterton Lakes National Park, Lechleitner (1955) considered Red foxes rare in Glacier National Park, Montana. Red foxes are uncommon in the Kananaskis area east of southern Banff National Park (Mill and Andersen 1980) and are considered hypothetical in Kananaskis Provincial Park (Salt 1976). They are even less common on the west slopes of the Rocky Mountains. Kootenay National Park wardens have observed only 4 red foxes between 1945 and 1978, while McCrory and Blood (1978) say that red foxes "... appear to be generally rare on the west slope of the Rockies at this latitude, and to have never been more than rare in [Yoho National Park]".

The red fox is very rare in both Banff and Jasper. Seventeen red fox sightings have been reported from 1976 to 1981. (Warden observations, Inventory files). In addition, 2 foxes were killed by motor vehicles in the Bow River valley in 1981. Only 4 fox tracks were observed in 46585 km-day of winter tracking transects in Banff and Jasper.

From the limited data collected since 1976 it appears that red foxes primarily inhabit lower elevations in the major river valleys. Of 19 fox records (13 in Jasper and 6 in Banff) 11 watersheds were represented, indicating that this species, although rare, is fairly widespread. Six of these observations were apparently the same animal, which remained near Signal Mountain fire lookout during the first week of July 1977.

Since an early report by Williamson (1916), in which he considered the red fox abundant in Banff National Park, most park researchers have remarked on its relative scarcity (Clarke 1940, 1942, Banfield 1958).

Soper (1970) gives a detailed account of the history of red fox in Jasper National Park since the 1890's. Red foxes were never common in Jasper and fox numbers were historically greater outside the eastern boundary of the park than within. He does however state that red foxes are moderately common and widespread in Jasper being "perhaps rather less numerous than coyotes". In the past five years red foxes have been much less abundant than coyotes. Carbyn (1972a) saw no foxes during the 1970-71

season in the Willow Creek area of Jasper National Park, although there were reports of foxes in the Rock Lake area north and east of the park boundary. Bowen (1978), while studying coyotes in the lower Athabasca valley reported that Red foxes "are present in low numbers throughout the year".

HABITAT

Red foxes occur in Banff and Jasper from montane valley bottoms to the alpine tundra, from 1180 to 2460 meters elevation. Of 19 records between 1976 and 1981, 8 were in the montane, 5 in winter. There are 8 records from the alpine ecoregion and all were during the summer. The remaining observations were 1 from the lower subalpine and 2 from the upper subalpine ecoregion. It is likely that the winter distribution of red fox is limited to low elevations because of deep snow at higher elevations.

Red foxes or their sign have been recorded (n=17) in a wide range of habitat types including: lodgepole pine (1), alpine heath meadow (8), Douglas fir/hairy wild rye (C1) (2), stunted timberline Engelmann spruce-subalpine fir open forest (2), and 1 record in each of lodgepole pine savannah, aspen/hairy wild rye-peavine (C16) forest, Engelmann spruce-subalpine fir forest and aspen-white spruce forest.

LIFE HISTORY

Most aspects of the ecology of the red fox have been studied in detail. However, most of these studies have involved the eastern or northern plains red fox of the United States. Little is known of the natural history of the red fox in boreal or mountain regions.

The red fox is primarily nocturnal or crepuscular although it may occasionally be seen during daylight particularly in winter (Storm 1965, Ables 1969). Of 92 red foxes seen in Banff and Jasper since 1945, 40 were winter sightings.

Although red fox no doubt breed within the park boundaries of Banff and Jasper, there is no proof of this. No fox dens have been reported from Banff or Jasper. There have been no observations of immature foxes in Banff since records have been kept. In Jasper immature foxes have been seen on only two occasions since 1952. Both records were of single animals, presumable dispersing juveniles, in the lower Athabasca River and Miette River watersheds.

According to Banfield (1974) an average five young are born in spring (March to May). Up to 17 young have been recorded in a single litter.

In Banff and Jasper only a single, indirect, record of predation has been noted. Hatter (1945) found a fox scat with Columbian ground squirrel remains at Sunset Pass. The red fox is an opportunistic hunter whose diet generally reflects the availability of its prey (Ables 1969). Prey items that have been referred to in the literature and are found in Banff and Jasper include: Varying hare, Red squirrel, Meadow vole, Deer mouse, American beaver, Muskrat, ungulate carrion, Ruffed Grouse, ducks, frogs, berries and grasses (Ables 1969, Banfield 1974, Johnson 1970). It is likely that the most important food items in Banff and Jasper are Varying hare, Columbian ground squirrel, small rodents and carrion.

The coyote is abundant in both Banff and Jasper National Parks and wolves are also common in Jasper. The scarcity of red foxes may in part be due to competitive exclusion by these two canid species. Mech (1970) mentions two cases of foxes being killed by wolves on Isle Royale and in northern Minnesota. A major potential food source for red fox, especially during the late winter and spring months, is ungulate carrion (Johnson 1970, Schofield 1960). Competition for this food source with coyotes and wolves could limit fox numbers.

MANAGEMENT CONSIDERATIONS

Three red foxes have been killed by motor vehicles since 1952 in Jasper National Park while 5 have been killed on highways in Banff since 1964. These are only reported instances. Any unnatural mortality of a species which is already as scarce as the red fox can be considered excessive. Prompt removal of ungulate kills along the highways and railways may reduce red fox mortality.

BLACK BEAR *Ursus americanus* BLAC

STATUS AND DISTRIBUTION

Black bears occur throughout most of continental Canada, Alaska, the U.S. Rockies, Coast Ranges, Appalachian Mountains, Arkansas and along the Gulf Coast from Florida to Louisiana (Jonkel 1978). Generally they are common throughout their range although they are less abundant in areas with dense population and have been extirpated in some midwestern and eastern states (Pelton 1982).

The black bear occurs throughout Alberta except in the southeast portion of the province. Historically, black bears were common throughout much of Banff and Jasper National Parks (Banfield 1958, Soper 1970) being more abundant in some areas such as the Athabasca Valley than in remote valleys (Soper 1970). Holroyd (1968) estimated there were fewer than 300 black bears in Banff National Park while Soper (1970) believed there were "several hundreds" in Jasper National Park. Currently the consensus on the number of black bears is around 120 in Banff and 200 in Jasper (park wildlife cards). These are very crude estimates since no detailed studies of black bears have been undertaken in either park.

Currently, black bears appear to be most abundant in the Athabasca, North Saskatchewan and Bow watersheds (Table 3.4) and are seen there relatively more frequently than grizzly bears.

HABITAT

Bears were specifically excluded from this inventory's terms of reference thus only random observations of bears and their sign were collected. These random observations of black bears by Canadian Wildlife Service and park staff provide the only information on the habitat preferences of this species in Banff and Jasper.

Black bears were observed most frequently on valley bottoms and on south-facing lower slopes (Tables 3.5, 3.6). However, many trails are located on these same slopes, thus creating an observer bias. There is no way to eliminate this bias from the data. However, black bears were observed relatively more frequently on flat valley bottoms than are grizzly bears.

Just over half the black bear sightings were on roadsides, at dumps and on other disturbed sites. The natural habitats with which black bears were most commonly associated were deciduous, mixed or lodgepole pine forests. Only a small proportion of the bear sightings were in open habitats (Table 3.7).

LIFE HISTORY

In Banff and Jasper, very little is known about the life history of black bears other than information taken from the general literature.

Food Habits

Canadian Wildlife Service staff observed bears foraging on a few occasions during the wildlife inventory. A black bear was observed feeding on buffaloberries and remains

Table 3.4. Geographic distribution of observations of black and grizzly bears in Banff and Jasper, 1975 to 1980; based on park wildlife cards and CWS observations.

Area	BlackBear #	%	GrizzlyBear #	%
Athabasca, North Saskatchewan, and Bow valleys	556	76	854	60
Other Main Range valleys	49	7	169	12
Front Range valleys	126	17	406	28
Total	731	100	1429	100

of these berries were found in 4 scats. Black bears were observed twice feeding on ants, on dandelions and on bearberry, and once each on garbage, clover, dry grass and black crowberry. Warden observations of black bear diet from 1945 to 1975 include lawn grasses(11 occasions), bearberry (4), elk carrion (2), garbage (1), fish (1), raspberry (1), grouse (1), and dandelions (1). Garbage is underrepresented in these figures since most bears observed at landfills were almost certainly feeding on garbage. The only records involving predation involved unsuccessful attacks on a moose and a sheep.

The above serves to illustrate the omnivorous nature of the black bear's diet. It is this omnivory, and the species' adaptability, that have given the black bear its long history of association with campgrounds, garbage dumps and restaurant garbage bins.

Productivity

Information on productivity of black bears in Banff and Jasper is sketchy (Table 3.8). Half of the bears that were classified were adults and 33.2% were young-of-the-year. Lindzey and Meslow (1980) found 13.8% of a hunted bear population in Oregon were young-of-the-year. There is observer bias in the Banff and Jasper data in that sows with young are more readily classified than single bears. However, black bears are considered to have a low reproductive rate since females do not breed until 5 to 7 years of age and have litters of 1 to 4 young only every second or third year (Pelton 1982). This is an important consideration for management since it implies that losses of adult females may have far-reaching impacts on populations.

From 1945 to 1975, there were 149 observations of sows with 269 cubs, or 1.81 young per female with cubs. In Jasper 58 sows were accompanied by an average of 2.02 young while in Banff 91 sows had an average of 1.67 young. These averages are based on observations throughout the whole summer; thus they do not represent the litter size at birth. Warden P. Kutzer observed the birth of a black bear cub on February 18, 1968 on the Norquay road near Banff townsite (Banff warden card).

Mortality

There are two or possibly three records of black bear mortality from natural causes and 636 deaths from unnatural causes (Table 3.9, 3.10). The largest cause of mortality is due to the destruction of "problem" bears due to inadequate garbage management. Mortality on highways and railroads are the second and third largest causes of mortality. Males are killed more frequently than females although age and sex of

Table 3.5. Slope aspects of bear sightings in Banff and Jasper, based on park wildlife cards, 1975 to 1980.

Aspect	BlackBear #	%	GrizzlyBear #	%
North	16	4 5	28	7.2
East	23	6 5	46	11.8
South	46	13 1	84	21.6
West	32	9 1	36	9.3
Flat	235	66 6	195	50.1
Total	352	99 8	389	100.1

bears killed was seldom recorded.

Hibernation

Very few black bear dens have been found in Banff and Jasper. Most are found in summer when they are unoccupied. Of four found in Banff all were in dirt banks in the montane ecoregion. Their orientation was north (1), south (1), and west (2). All were in coniferous forest. Two were at the toe of banks and two at the top of banks.

The first black bear sightings in the spring usually occur in the last week of March or the first half of April. The earliest sighting prior to 1975 was in 1958 in Jasper townsite. Black bears are frequently observed during the month of October. The latest sighting is 1972 in Banff townsite. Most black bears hibernate from October to April in these parks.

Mating

There are two observations of mating black bears, one near the Banff warden station in 1957 (park wildlife card) and an unsuccessful attempt involving a female with two cubs near Eisenhower warden station in 1968 (park wildlife card).

MANAGEMENT CONSIDERATIONS

A great deal of effort has been expended to manage black bears. In about thirty years 523 were recorded destroyed and 547 transported. The handling of bears, dead or alive, is not fully recorded; hence these figures are conservative. The historical record shows that fewer black bears were killed or destroyed in Banff in the 1970s than previously but there was no decrease in Jasper (Table 3.10).

There are two obvious causes of the bear problem: garbage and co-habitation of habitats by bears and humans. The history of the problem in Banff and Jasper dates to the first arrival of humans, and is long and complex. The solution was acknowledged as early as 1945. In that year Banff's Chief Warden Mitchell recommended that garbage be collected twice weekly, that no edible garbage be dumped at the nuisance grounds (landfill) and that a pamphlet be prepared on bear-human interactions for distribution to the public. While there were various efforts made to solve the garbage-bear problem, not until 1980 were truly bear-proof garbage containers installed. In Banff, garbage is trucked out of the park, while the Jasper sanitary landfill is now enclosed by an effective electric fence (J. Woodrow, pers. comm.).

Table 3.6. Topographic position of bear sightings in Banff and Jasper, based on park wildlife cards, 1975 to 1980.

Position	BlackBear		GrizzlyBear	
	#	%	#	%
Ridge Crest	6	1.5	5	1.1
Upper Slope	8	1.9	41	9.2
Mid Slope	24	5.8	40	9.0
Lower Slope	52	12.7	59	13.3
Valley Bottom	321	78.1	299	67.3
Total	411	100.0	444	99.9

The problem of accidental encounters with bears in the wild is even older than the garbage problem. In 1826 Thomas Drummond (1830) encountered a sow grizzly bear with cubs in Jasper and narrowly missed a mauling thanks to the timely arrival of three Indians on horseback. Black bears will also attack humans if surprised or threatened, and may occasionally perceive humans as prey. The first documented human death due to a bear attack was caused by a black bear which had become habituated to handouts in Jasper. Black bears injure more people in western North American than do grizzly bears.

While both species of bears are of management concern and both are frequently trapped or tranquilized, black bears are more frequently destroyed and grizzly bears are more likely to be transported to "remote" locations. The dearth of recent black bear sightings in both parks may indicate that the cumulative impact of all types of unnatural mortality have reduced black bear populations to a very low level.

A study of the population size, dynamics and habitat preferences of Banff and Jasper's black bear populations is needed immediately. Little is known about these populations, yet bears continue to be destroyed. Further, the conflict with humans and black bears will continue if intense human activity continues in prime black bear habitat. Recent studies on grizzly movements by Russell et al. (1979) and on grizzly habitat by Hamer and Herrero (1983) should be duplicated for black bears.

GRIZZLY BEAR *Ursus arctos* GRIZ

STATUS AND DISTRIBUTION

The grizzly bear occurs throughout most of Alaska, Yukon, British Columbia, western Alberta and western and northern Northwest Territories (Jonkel 1978). Historically it occupied most of the western half of North America but was extirpated from Mexico, most of the United States and the Canadian Prairies (Rausch 1963). Grizzly bears are still common in the northern part of their range but are becoming increasingly scarce in the south (Craighead and Mitchell 1982).

Historically, grizzly bears have been widely distributed and fairly common in both parks. Drummond (1930) encountered a grizzly sow with cubs in 1826 along the Athabasca River and Palliser (1860) reported grizzlies at Kananaskis Pass in 1858. Virtually every expedition into the mountains makes mention of grizzlies in their reports. Clarke (1942) considered Jasper 'fully-stocked' with grizzlies and estimated there were

Table 3.7. General habitats of bear sightings in Banff and Jasper, from warden records 1975 to 1980.

Habitat	BlackBear		GrizzlyBear	
	#	%	#	%
Man-made	212	52.0	130	30.3
Alpine	3	0.7	50	11.7
Deciduous and Mixed	64	15.6	40	9.3
Pine Forest	34	8.3	33	7.6
Spruce-Fir Forest	18	4.4	45	10.5
Other Coniferous Forest	14	3.4	20	4.7
Shrub	19	4.6	20	4.7
Slidepath	17	4.2	38	8.9
Grassland	10	2.5	33	7.5
Other	17	4.2	20	4.7
Total	408	99.9	429	99.9

100 in Banff (Clarke 1940), an estimate that Banfield (1958) considered too generous. As of 1980, the warden services considered there to be 110 grizzly bears in Jasper and 55 to 80 in Banff. More accurate population estimates are difficult to obtain.

HABITAT

Russell et al. (1979) and Hamer and Hererro (1983) have conducted detailed studies of grizzly bears in the two national parks. The reader is referred to those two reports for details. Because of the bear research program taking place at the same time as the ecological land inventory program, grizzly bears were not included in this inventory's terms of reference. The following information is gleaned from random (unsystematic) observations collected by park wardens and Canadian Wildlife Service staff from 1945 to 1980.

Grizzly bears were observed most frequently on flat valley bottoms and on south-facing lower slopes (Table 3.5, 3.6). This distribution is biased by the location of many observers - on valley bottoms and lower slopes. When compared to sightings of black bears, grizzlies were observed relatively more often on mid and upper slopes with east and south exposures. Grizzly bears were encountered more frequently in Front Range valleys (ie. the eastern parts of the parks) than were black bears.

Only 30% of the sightings of grizzlies were on man-modified landscapes (roadsides, campgrounds, etc.) compared to 52% of black bear records. In contrast, grizzly bears were observed more frequently in the alpine, in spruce-fir forests, on slidepaths and on grasslands. These habitats reflect a preference (3 of 4) for open, unforested areas.

LIFE HISTORY

Again the reader is referred to Russell et al. (1979) and Hamer and Herrero(1983) for details of grizzly bear biology. The following details were derived from random observations.

Food Habits

Table 3.8 Age and sex of black bears observed in Banff and Jasper, based on park wildlife cards to 1980.

Age/Sex	BANFF #	BANFF %	JASPER #	JASPER %
Adult Male	322	26.2	189	10.9
Adult Female	293	23.8	502	28.9
Unkown Adult	71	5.8	190	11.0
YOY	408	33.2	513	29.6
YLY	136	11.1	341	19.7
Unknown	1961	-	1247	-
Total	3191	100	2992	100

There are 42 records of grizzly predators on ungulates between 1945 and 1976 (Table 3.11). Moose and elk are the prime prey but mule deer and bighorn sheep are also taken. Unsuccessful attacks by grizzlies on mountain goat, caribou and moose have also been recorded. It is not clear from the available records how many of these ungulates were already dead and merely being scavenged by the bears, nor the age-sex distribution of their prey.

In addition, the following food items were recorded in the 1945 to 1976 cards:
- unspecified roots (9 observations)
- buffaloberries (7)
- Columbian ground squirrel (6)
- grass (2)
- garbage (2)
- dandelions (1)
- young grizzly bear (1)
- hoary marmot (1)
- ants (1)

Canadian Wildlife Service staff observed the following diet items between 1975 and 1980:
- buffaloberries (3)
- grass (1)
- *Equisetum* (1)
- ants (1)
- roots (18)
- Columbian ground squirrel (9)
- hoary marmot (2)
- unknown items (101)

These lists represent the omnivorous nature of the grizzly bear.

Productivity

Information on the age and sex composition of the grizzly population is limited (Table 3.8). Half of the classified bears were adult and 29.6% were young-of-the-year. This is higher than the level of 18.6% cubs in Yellowstone grizzly population (Jonkel 1980). As stated in the black bear account, however, there are considerable biases in the random observations.

Table 3.9. Recorded mortality and handling of black bears in Banff and Jasper, 1945 to 1978, based on park wildlife cards, bear files and superintendent reports.

	BANFF				*JASPER*				
Cause	M	F	YUNK		M	F	YUNK		TOTAL
Highway	15	4	3	21	1	5	2	21	**72**
Railroad	17	1	17	35					
Poached	1	1	3						
Disease	1	1							
Black bear	1	1							
Unknown	1	1							
Destroyed	12	10	62	10	17	9	42	55	**523**
Moved	45	20	163	26	4	7	15	142	**575**

From 1945 to 1975, there were 160 observations of sows with 312 young-of-the-year, or 1.95 young per female. This figure includes cubs up to 10 months old and is only slightly below the average of 2.24 in Yellowstone litters (Jonkel 1980). These rough data suggest that the Banff-Jasper grizzlies are reproductively healthy.

Mortality

All recorded mortality of grizzly bears was from unnatural causes. Relatively few grizzly bear deaths were recorded on the highways and railroads, but a considerable number were destroyed in management actions. The records of bears recorded as destroyed or transported are incomplete, especially in Jasper National Park, and the age and sex of most bears was not recorded.

Hibernation

Vroom, Herrero and Ogilvie (1977) presented a relatively complete picture of den sites of grizzly bears in Banff National Park. Den sites were in areas when snow accumulates, with aspects from NNE to ESE, average mean altitude of 2,280m (upper subalpine), and average slopes of 33°. Grizzlies normally den during November and emerge in early April.

MANAGEMENT CONSIDERATIONS

Grizzly bears are among the most frequently discussed species of wildlife in the national parks. Since they are a threat to human safety they are frequently removed from garbage areas, campgrounds and townsites. Occasionally there are threatening encounters between bears and humans in their natural habitat. These two concerns, garbage and cohabitation of habitat by bears and humans have been addressed in recent management plans and action. Bear-proof garbage containers are in place in most parts of the two parks. In Banff, garbage is transported to Calgary. In Jasper, the sanitary landfill site was enclosed with electrified fencing in 1980. In Banff, a project is underway to map grizzly habitat which may ultimately lead to relocation of trails and campgrounds away from these areas. If these two objectives are met grizzly encounters should become less frequent than they are now.

Table 3.10. Average annual recorded mortality and handling of black bears for the last four decades in Banff and Jasper.(ND = no data)

Decade	BANFF		JASPER	
	Destroyed	Handled	Destroyed	Handled
1940's	4	ND	ND	ND
1950's	14	ND	47*	36*
1960's	15	32	15	9
1970's	5	17	14	35

* One year's data only.

AMERICAN MARTEN *Martes americana* **MART**

STATUS AND DISTRIBUTION

The marten is locally common in forested habitats across Canada. Its range and numbers have been reduced in the last century because of logging, forest fires and over-trapping (Banfield 1974).

In Alberta pine marten occur through the northern boreal forest and the length of the Rocky Mountains, being absent from the prairies and aspen parkland (Soper 1964). Marten are widely distributed and relatively abundant in both the southern Rocky Mountains of Waterton Lakes National Park (Nielsen 1973) and the Main Ranges of Yoho National Park (McCrory and Blood 1978).

The marten is the most abundant carnivore in Banff and Jasper. A total of 6366 marten tracks were tallied during 4658.5 km-day of winter track transects (13.7 tracks/10km-day) between 1975 and 1981. During this time 131 martens were observed (Warden files, inventory files). They are twice as common in Jasper (21 tracks/10km-day) than Banff (10 tracks/10km-day). Main Range watersheds support higher densities of martens than do the Front Ranges (18 vs 14 tracks/10km-day). This is probably because of the greater extent of mature conifer forest, which is preferred marten habitat, in the Main Ranges.

Marten tracks were encountered in every watershed censused during winter in Banff and Jasper. From winter tracking, marten are most common in the following watersheds in Banff (in decreasing order of importance): upper Bow River, Clearwater River, middle Bow River, upper North Saskatchewan River; and jasper: Fiddle River, Meadow Creek, Cairn River, Smoky River, Sunwapta River.

HABITAT

In Banff and Jasper American martens occur in greatest numbers in mature Engelmann spruce-subalpine fir and subalpine larch-subalpine fir/grouseberry-everlasting (C23) forest in the upper subalpine ecoregion, although they frequent a wide range of habitats from montane spruce and balsam poplar-white spruce forest to stunted timberline forests.

Winter tracking yielded the following indices of marten use per ecoregion based on ecosites in which martens occurred:

upper subalpine (22.0 tracks/10km-day)
lower subalpine (13.6)

Table 3.11. Grizzly bear ungulate prey (as recorded on Banff and Jasper warden wildlife cards 1945 to 1976)

		SUMMER						WINTER						
Park	Species	M	F	YOY	YL	UNK	**Total**	M	F	YOY	YL	UNK	**Total**	Year-round total
BANFF	Mule deer	0	0	0	0	1	**1**	0	0	0	0	0	**0**	1
	Elk	1	0	0	1	2	**4**	1	1	0	0	1	**3**	7
	Moose	0	2	1	0	2	**5**	2	0	0	0	0	**2**	7
	Bighorn sheep	1	0	0	0	0	**1**	0	0	0	0	0	**0**	1
	Mountain goat	0	0	0	0	(3)	**(3)**	0	0	0	0	0	**0**	(3)
JASPER	Mule deer	0	2	1	0	0	**3**	0	0	0	0	0	**0**	3
	Elk	1	3	1	1	1	**7**	0	0	0	0	0	**0**	7
	Moose	4(1)	4(1)	1	1	3	**13(2)**	0	0	0	0	1	**1**	14(2)
	Caribou	0	0	0	0	0	**0**	0	0	0	0	(1)	**(1)**	(1)
	Bighorn sheep	2	0	0	0	0	**2**	0	0	0	0	0	**0**	2

( )=unsucessful attempts.

montane (10.6)
alpine (3.0)

Seven of the ten most highly ranked ecosites are upper subalpine. The elevational range of American marten is from 1080 to 2720 m.

The high density of marten in the upper subalpine ecoregion is related to the occurrence of mature Engelmann spruce-subalpine fir (with larch in Banff) forests in this ecoregion. Engelmann spruce-subalpine fir forest is considered to be ideal marten habitat in the Rocky Mountains by a number of researchers (Cowan and Mackay 1950; Koehler and Hornocker 1977; McCrory and Blood 1978). In Yoho National Park, McCrory and Blood calculated a winter tracking index of 40 marten tracks/10km-day in an area of mature Engelmann spruce-subalpine fir forest which they considered to be optimum marten habitat in that park. The most important vegetation type for marten in Banff and Jasper is open subalpine larch/heath forest forest which supported a similar density of marten (297 tracks in 65.9 km-day; 45 tracks/10km-day). Closed spruce-fir forest of the type described as optimum marten habitat in Yoho had 19 tracks/10km-day (N=1007 km-day).

Open and closed black spruce forests are preferred marten habitat in the lower subalpine ecoregion. Lodgepole pine-spruce forests are also important. In Banff and Jasper both of these forest types support high densities of Gapper's red-backed voles. Pine-spruce forests, especially at early growth stages, are also favoured Varying hare habitat.

Marten density in the montane ecoregion is close to that in the lower subalpine. Montane habitats that support highest marten densities include Douglas fir/hairy wild rye (C1) forest, aspen/hairy wild rye-peavine (C16) forest, and mixed Douglas-fir/white spruce stands. McCrory and Blood (1978) also identified Douglas-fir forest as a preferred marten habitat in Yoho National Paek.

Marten using the alpine ecoregion during winter were usually travelling to and from clumps of krummholz forest at treeline, or to talus or colluvial landslides where they presumably hunted pikas or deer mice. Marten rarely hunt in open alpine meadows during winter.

Another important winter habitat of American martens is lodgepole pine-dominated burns (17 tracks/10km-day). This type of habitat is most common in the Front Ranges, and is typified by the Flint's Park burn in the Cascade watershed of Banff. Koehler and Hornocker (1977) found that open meadows and burns were avoided by marten during winter but suggested that they were probably used in the summer and fall if adequate food and cover were available. Although voles are not abundant in open pine forests in Banff and Jasper, Varying hares are common.

Marten tracks are most abundant in winter where snow depths are from 121 to 125 cm.

LIFE HISTORY

Marten eat a wide variety of food items, being adept at capturing small mammals, even in deep snow. A detailed account of food habits of the marten in the Canadian Rocky Mountains is given by Cowan and Mackay (1950). The following is a list of food sources martens used between 1945 and 1980 (Warden files, inventory files):

small rodents (3)
Varying hare (5)
Red squirrel (1)
ungulate carrion
grouse (sp) (3)
woodpecker (sp) (1)
American Robin (1)
garbage (14)

Both the red-backed vole (Cowan and Mackay 1950, Lensink et al. 1955, Weckworth and Hawley 1962, Koehler and Hornocker 1977) and the meadow vole (Francis and Stephenson 1972) have been cited as important prey species. A number of studies have shown that deer mice are of low importance to martens even when they are very abundant. Weckworth and Hawley found that Heather vole remains occurred in approximately 10% of marten scats in the Rocky Mountains of Montana.

Varying hares and red squirrels have been considered important prey species in some areas (Quick 1955, Marshall 1946, 1951) but these species are generally of low importance to martens (Strickland et al. 1982). Other foods that have been reported in the marten's diet and occur in Banff and Jasper include Northern flying squirrels, pikas, berries and insects (Banfield 1974). Marten scats laden with berries of *Empetrum nigrum* and *Shepherdia canadensis* are frequently seen in August and September.

Martens probably have few natural enemies because of their stealth and arboreal habits. A coyote was seen with a marten in its mouth in Jasper. Other potential predators are fisher, lynx, great horned owls and golden eagles (Banfield 1974).

Marten breed during July and August and after a total gestation period, including a delayed implantation period, of 220 to 275 days the young are born in March or April. Litter size varies from 1 to 4 (average 2.6) (Banfield 1974). No information concerning reproduction is available from Banff or Jasper.

MANAGEMENT CONSIDERATIONS

The marten's status is secure in both Banff and Jasper.

FISHER *Martes pennanti* **FISH**

STATUS AND DISTRIBUTION

The fisher occurs locally at low population densities in forested habitat from New Brunswick to British Columbia (Banfield 1974). Its dependence on closed forest, and its susceptibility to trapping, have led to a considerable reduction in range and population levels (Brander and Books 1973). The northern limit of its present range is the southern Yukon and Mackenzie District. It is absent from the prairies and aspen parkland of Alberta, Saskatchewan and Manitoba and has been extirpated in southern Ontario and Quebec, and parts of the Maritimes.

The fisher is uncommon in Alberta, ranging from the central Rocky Mountains east and north into the boreal forest (Soper 1964). It is rare in the Rocky Mountains. The last fisher sighted in Waterton Lakes National Park was in 1910 (Nielsen 1973). Fishers are considered rare or non-existent in Kananaskis Country based on ranger interviews and trapping returns (Mill and Andersen 1980) although two possible sets of fisher tracks were reported in an inventory of Kananaskis Provincial Park in the fall of 1976 (Salt 1977). McCrory and Blood (1978) concluded that fishers are very rare in Yoho National Park while Banfield (1958) indicated that Fishers were extirpated in the Kootenay region south of Yoho.

The fisher is widely distributed but very rare in Banff and Jasper. Only 7 fisher sightings were recorded in Banff and Jasper between 1975 and 1980 (Inventory files, Park warden files). Two sightings were in 1975 in the lower Snake Indian River valley while single sightings were recorded in the upper Athabasca River middle Bow River, Clearwater River, Mistaya River and Sunwapta River watersheds. Only 10 fisher tracks were noted during 45685 km-day of winter track transects in Banff and Jasper. They were in the following watersheds: lower Athabasca River, middle Bow River (X2), Bryant Creek, lower Maligne River, upper North Saskatchewan River, Siffleur River, Smoky River, and upper Spray River. In addition, tracks were observed in the upper Maligne River, Siffleur River and upper Athabasca River watersheds.

Fishers have been very rare in Jasper since at least the 1890's (Soper 1970). Park wildlife investigations by Hollister (1912), Andersen (1938) and Clarke (1942) all remark on the scarcity or absence of fisher in Jasper. Only seven fisher observations were recorded by the Jasper National Park warden service from 1944 to 1976.

In Banff, Banfield (1958) states that "fisher tracks are occasionally reported from the northern part of Banff". Anderson (1938) and Clarke (1940) fail to mention the fisher in their accounts of Banff Park wildlife. Banff National Park wardens reported only five fisher observations between 1944 and 1976. It is probable that this species was never abundant in the Rocky Mountains.

HABITAT

Closed coniferous forests in the lower subalpine ecoregion are preferred by fisher in Banff and Jasper National Parks.

Of 20 observations, 14 were in the lower subalpine ecoregion. Three records each were in the montane and upper subalpine ecoregions. None were recorded in the alpine.

Of 20 fisher records for which habitat was recorded the following habitats were used:

Engelmann spruce-subalpine fir forest (7)
lodgepole pine-spruce forest (7)
lodgepole pine-dominated burn (2)
subalpine larch-subalpine fir/grouseberry-everlasting (C23) forest (1)

Engelmann spruce–subalpine fir open timberline forest (1)
white spruce/juniper/bearberry (017) forest (1)
stream channel (1)

Hagmeier (1956) states that in mountainous country of western North America fisher coexist in the lowlands with marten, while only marten live at the higher elevations. Quick (1953) however, felt that the fisher and marten were uniformly distributed in timbered areas of the mountains and foothills of British Columbia. The former statement appears most applicable to Banff and Jasper, though marten occur at much higher densities in all habitats and elevations.

Extensive fires in the late 1800's and early 1900's probably destroyed so much of the mature coniferous forest upon which the fisher depends that the species was unable to make a comeback following heavy trapping around the turn of the century. In light of the succession of these burns to more mature forest today, fishers may become more abundant in the southern Rockies.

LIFE HISTORY

The fisher's gestation period is prolonged due to delayed implantation of the embryo. Mating occurs in March or April (Banfield 1974). Breeding takes place as soon as a week after the litter is born (Hall 1942). The average litter size is 2.7 (1–4) (Banfield 1974). In Maine, Wright and Coulter (1967) found that the potential rate of reproduction in the fisher is higher than that of the marten. No breeding evidence has been noted in either Banff or Jasper.

Only a single record of predation by fisher has been noted in Banff and Jasper. A varying hare was killed near the Fiddle River bridge in Jasper in December 1959 (Jasper warden cards).

Although no food habit studies have been conducted in the Rocky Mountains, elsewhere the fisher is basically an opportunistic hunter. The varying hare is the most prevalent food item in the fishers' diet throughout much of its range (Branden and Books 1973). Other food items mentioned by Banfield (1974) include Red squirrel, Northern flying squirrel, Gapper's red-backed vole, shrews, American porcupine, Deer mouse, mink, Muskrat and ungulate carrion.

In Banff and Jasper, the closely related pine marten occurs at much higher densities than the fisher. It is questionable as to whether this is due to competitive exclusion or to the fact that the mountainous environment is better suited to marten. Clem (1975) found that fisher feed on larger prey than marten and concluded that the diets of the two species in southern Ontario did not overlap significantly enough to result in competitive exclusion.

MANAGEMENT CONSIDERATIONS

The fisher has probably always been rare in Banff and Jasper, and in the Rocky Mountains in general. Overtrapping, logging and fires have been the most critical factors affecting fisher populations outside of the National Parks (Brander and Books 1973). Since of these factors only fire has affected Banff and Jasper -- and even so has not eliminated much of the naturally mature forest along the western sides of the parks -- it is probable that the present low population levels of fishers in Banff and Jasper are a result of naturally-occurring environmental conditions. Attempts to reintroduce or increase numbers of fishers would probably not be successful.

SHORT-TAILED WEASEL *Mustela erminea* **ERMI**

STATUS AND DISTRIBUTION

Short-tailed weasels are very widely distributed across Canada, being absent only from portions of the prairie grain belt and a few offshore islands (Banfield 1974).

Short-tailed weasel occur throughout Alberta except in the prairies and southern parkland (Soper 1964). They are very common in the Rocky Mountains. They are considered the most common mustelid in Waterton Lakes and Yoho National Parks (Nielsen 1973, McCrory and Blood 1978). Salt (1977) found them to be widespread and fairly abundant in Kananaskis Provincial Park.

Short-tailed weasels are very common and widely distributed in Banff and Jasper. 1793 short-tailed weasel tracks were recorded in 4658.5 km-day of winter tracking transects, or 3.9 tracks/10km-day. Based on these results they are the second most abundant carnivore, next to the marten, in Banff and Jasper. They occur in smaller numbers in Banff (3.0 tracks/10km-day) than Jasper (5.3 tracks/10km-day), and are relatively ubiquitous.

Short-tailed weasels were seen on only 7 occasions in Banff and Jasper between 1975 and 1980. The great disparity between track and sight records indicate the secretive nature of this animal.

Watersheds in which short-tailed weasel track densities were highest include Willow Creek, upper Snake Indian River and Miette River, all in northern Jasper. However, the high densities of short-tailed weasel in these watersheds may be an artifact of the high number of transects in favoured Short-tailed weasel habitat. No difference in abundance was noted between the Main and Front Ranges.

HABITAT

Short-tailed weasels use a variety of habitats in Banff and Jasper, being most common in open sedge, shrub and coniferous forest habitats.

They have an more even altitudinal distribution than most other carnivores in the mountains. Short-tailed weasel densities were highest in the upper subalpine (5.2 tracks/10km-day), followed by the montane (4.0 tracks/10km-day) and lower subalpine (3.6 tracks/10km-day). The alpine ecoregion has the lowest track density (2.1 tracks/10km-day) but Short-tailed weasels were the commonest carnivore in the alpine. The elevation range is from 1080 to 2800 meters.

Preferred habitats in the montane ecoregion are shrubby meadows, particularly willow-green alder/bluebell (S6) stands, white spruce/shrubby cinquefoil/bearberry (O3) forest and, to a lesser extent, mixed poplar/spruce forest. In the lower subalpine Short-tailed weasel occur most commonly in sedge meadows (H11), open spruce forest on alluvial fans (O18), black spruce-lodgepole pine/willow/sedge (C8) forest and lodgepole pine-dominated burn (in decreasing order of importance). Sedge and shrub meadows are used most heavily in the upper subalpine ecoregion, followed by Engelmann spruce-subalpine fir open forest and colluvial rubble deposits adjacent to Engelmann spruce-subalpine fir forest.

Little research has been done on short-tailed weasel habitat use in mountain ecosystems. Referring to Jasper National Park, Soper (1970) wrote, "Typical environment favoured by these animals include the usual Canadian Zone elements of mixedwood forest, poplar-willow flats, rocky slopes, and ravines and at least the lower altitude rock slides". McCrory and Blood (1978) found that Short-tailed weasels in Yoho National Park were most abundant in Douglas-fir and deciduous or mixed forests, and avalanche slope habitats, with low numbers in pine woods, logged or burned areas, and wetlands. Our

results indicate that Short-tailed weasels occur in low numbers in Douglas-fir and avalanche slopes and high numbers in wetlands and burns, indicating some regional disparity in habitat use.

The two most highly ranked vegetation types for short-tailed weasel, montane high shrub (S7) and open white spruce (018), were among the top ranked vegetation types for small mammal abundance and diversity. Short-tailed weasel habitat choice is probably largely influenced by small mammal diversity and abundance.

LIFE HISTORY

Short-tailed weasels breed during the summer and the young are born the following spring (Soper 1970). An adult Short-tailed weasel and 6 young were seen at Maligne Lake on 21 June 1971 (Warden Observation). According to Rand (1948), average litter size for the Short-tailed weasel is five (4 to 9).

Banfield (1974) describes the diet of the Short-tailed weasel as follows:

mice	50.7%
shrews	22.5%
hares	8.7%
porcupine	6.2%
birds	5.0%
squirrels	2.5%
fish	1.2%

Other items include ground squirrels, chipmunks, pikas, snakes and frogs. No predator-prey interactions were observed in Banff and Jasper. Banfield also notes that short-tailed weasel populations may rise and crash according to small mammal population cycles.

MANAGEMENT CONSIDERATIONS

The status of the Short-tailed weasel in Banff and Jasper is relatively secure.

LONG-TAILED WEASEL *Mustela frenata* **LOWE**

STATUS AND DISTRIBUTION

The Long-tailed weasel is associated most often with shortgrass plains, northern prairie, or aspen parkland habitats (Soper 1964, Banfield 1974). It also occurs, in lesser numbers, in the deciduous regions of eastern Canada and the foothills and mountains of Alberta and British Columbia, where it has been seen in alpine tundra up to an elevation of 3025 m.

In Alberta the long-tailed weasel inhabits the entire southern portion of the province, ranging through the parklands to a latitude of 55°N (Soper 1964). It is widely distributed but uncommon in the Rocky Mountains, being somewhat more abundant in southern areas. In Waterton Lake National Park, Long-tailed weasels are rarely seen but are considered to be "moderately well represented" (Nielsen 1973). None were found by Salt (1977) in Kananaskis Provincial Park. Four of 13 weasels observed by Kootenay National Park wardens from 1944 to 1978 were identified as long-tailed (Kootenay Park warden files). They are rare in Yoho National Park (McCrory and Blood 1978) where a single roadkill in 1976 is the only direct evidence of its presence in the park. Five sets of tracks were recorded during 147 kms of winter tracking in Yoho.

Long-tailed weasels are uncommon in Banff and Jasper. Between 1976 and 1981 there were 27 records including 13 sightings, 24 sets of tracks on 12 track transects, one scat and one track. Long-tailed weasels or their sign have been seen in 21 of 64

watersheds censused. They appear to be fairly evenly distributed throughout both parks, being more common in the Front Ranges (22 records) than the Main Ranges (5 records). There have been more recorded in Banff (17) than Jasper (10).

The tracks of the Long-tailed weasel and Short-tailed weasel are difficult to separate. Only 3 of 8 observers felt capable of separating the two kinds of tracks. Among these observers there is a consensus that the Short-tailed weasel is by far the more common species in Banff and Jasper, however the Long-tailed weasel is probably somewhat more common than the above records indicate.

Weasel live-trapping was conducted in both Banff and Jasper to assess the abundance of Long-tailed weasel relative to Short-tailed weasel. No weasels were captured. A more intensive trapping program would be needed to determine the extent to which Long-tailed weasels occur in Banff and Jasper.

The Long-tailed weasel has probably never been common in Banff or Jasper National Parks. One of the earliest reports from Banff were two specimens collected by Cowan in 1930 for the National Museum of Canada (Banfield 1958). Clarke (1942) wrote that the range of this species includes the eastern slope of the Rocky Mountains. Park wardens have reported six Long-tailed weasel sightings between 1968 and 1976. Two of these sightings were at Vermilion Lakes, and 1 each at the Buffalo Paddock, lower Cascade River, Castle Lookout, and along the trail to the North Saskatchewan glacier.

According to Soper (1970) the earliest record of the long-tailed weasel in Jasper is from the 1939 field notes of R.M. Anderson. Clarke (1942) wrote, "Occasional reports indicate that this species may be found in Jasper Park". Hall (1951) reported a specimen taken at Moose Pass. There were no Long-tailed weasels reported by Jasper wardens between 1945 and 1978. Soper (1970) describes the Long-tailed weasel as "... unquestionably very thinly dispersed in the northern Rockies of Alberta".

HABITAT

Although Long-tailed weasels use a wide variety of habitat types in Banff and Jasper, they appear to be commonest in low elevation coniferous and upper subalpine Engelmann spruce-subalpine fir open forest.

The elevational range of Long-tailed weasels in Banff and Jasper is from 1080 to 2490 meters. 12 of 30 records are from the lower subalpine ecoregion, 8 each from the montane and upper subalpine, and only 2 from the alpine ecoregion.

There have been 28 Long-tailed weasel records for which habitat type has been recorded. They include:

lodgepole pine forest (9)
Engelmann spruce-subalpine fir open forest (5)
Engelmann spruce-subalpine fir forest (2)
montane meadow (2)
alpine heath meadow (2)
grassy avalanche slope (H14) (1)
montane shrub meadow (1)
lower subalpine shrub meadow (1)
upper subalpine shrub meadow (1)
upper subalpine meadow (1)
Engelmann spruce-whitebark pine/false azalea (C12) forest (1)
mixed poplar/conifer forest (1)
aspen/hairy wild rye-peavine (C16) forest (1)

McCrory and Blood (1978) found that this species occurs less commonly in the alpine, being most abundant at lower elevations in burns, river flats, or forested areas near clearings. Soper (1973) reported that long-tailed weasels in Waterton Lakes National Park rarely range above treeline but inhabit prairie-parkland and mixedwood forest in the

montane and subalpine ecoregions.

LIFE HISTORY

There is only one confirmed observation of successful predation by a Long-tailed weasel in Banff or Jasper. John Pitcher (Jasper Interpretive Service, pers. comm.) observed an adult carrying voles to a den beneath a clump of krummholz spruce near Cavell meadow in Jasper (August 1980). A Long-tailed weasel was seen stalking a magpie at Vermilion Lakes on August of 1968 (Warden observation). On November 1978 Long-tailed weasel tracks were observed in rock talus near the south end of Amethyst Lake; a similar observation in January 1980 in the Fiddle River valley suggests that pika may be a winter food item. In his 1939 field notes Anderson mentions both the Long-tailed weasel and Short-tailed weasel as the principal enemies of the pika.. "following the little animals into their holes in the crevices of the rock slides."

Prey species occurring in Banff and Jasper that have been listed as prey of long-tailed weasels in other studies include Meadow vole, Deer mouse, chipmunk, pika, Red squirrel and even American porcupine (Banfield 1974). Of these, mice and voles are the most frequently used prey item in most studies (Polderboer et al. 1941, Quick 1951, Fitzgerald 1977). Ground-nesting birds and their eggs are also part of their diet (Banfield 1974).

Long-tailed weasels mate in July and August yielding a litter of from 3-9 young during March and April (Banfield 1974). Young weasels have only been seen once. An adult and 2 young were observed by John Pitcher in the Cavell meadows in August 1980.

MANAGEMENT CONSIDERATIONS

Several of the available records of Long-tailed weasels are of roadkills. Because of their tendency to prey on Columbian ground squirrels which commonly colonize seeded roadsides, these weasels are frequently exposed to the danger of vehicle traffic.

LEAST WEASEL *Mustela nivalis* **LEWE**

STATUS AND DISTRIBUTION

The Least weasel is widely but sparsely distributed in most of Canada except the Maritimes, southern Ontario and Quebec, the northeast barrenlands of the Northwest Territories, and coastal British Columbia (Banfield 1974).

It occurs over most of Alberta with the possible exception of the arid southeast corner (Soper 1964). The Least weasel is a rare mammal in the Rocky Mountains. There are only 5 records from Waterton Lakes National Park, all since 1967 (Nielsen 1973). No Least weasels have been reported from Kananaskis Country (Salt 1977, Mill and Andersen 1980). McCrory and Blood (1978) consider the Least weasel present but very rare in Yoho National Park.

The Least weasel is a widespread but rare member of the fauna of Banff and Jasper. During the inventory Least weasels were recorded 35 times. A single animal was captured in a small mammal live trap in the lower Athabasca valley in August 1979. All other records were tracks; 27 were on winter tracking transects and seven were random observations. There were 24 records in Jasper and 11 in Banff in a total of 18 watersheds. The Least weasel is apparently less common in Banff than in Jasper and is about 15 times less common than the short-tailed weasel.

Little is known of the historical status of the least weasel in Banff and Jasper. The sole sight record in Jasper prior to the commencement of this inventory was a

specimen taken by Spreadborough at Miette River 1898 (Anderson 1919). Soper (1970) noted several least weasel tracks along the headwaters of the Wildhay River near the north boundary of Jasper during the winter of 1913. Carbyn (1972a) noted "tracks of what appeared to be least weasel" in the meadows west of Rock Creek.

That Banfield (1958) did not even mention the least weasel in his report on Banff wildlife attests to its scarcity. There are three warden records of least weasel, a pair at Silverton Creek in 1955, one in 1968 at Vermilion Lakes, and one in 1973 from the Plain of 6 Glaciers area.

HABITAT

The Least weasel inhabits a wide range of habitats (Banfield 1974). In Banff and Jasper Least weasels were recorded in eleven different habitats. The most preferred habitats were lower subalpine lodgepole pine-spruce forest and upper subalpine Engelmann spruce-subalpine fir forest.

Least weasel tracks have been seen from 1080 to 2260 meters elevation in Banff and Jasper, with the most important ecoregion being the lower subalpine ecoregion, in which 19 of 35 least weasel records have been made. The remaining records were divided between the other ecoregions as follows: upper subalpine (10), montane (5), alpine (1).

Least weasel habitats and their relative use, based on 34 track and one sight record, are:

- lodgepole pine-spruce forests (9)
- Engelmann spruce-subalpine fir forest (7)
- Engelmann spruce-subalpine fir/willow/hairy wild rye (O18) forest on lower subalpine alluvial fans (6)
- Engelmann spruce-subalpine fir open timberline forest (3)
- unspecified shrub (2)
- upper subalpine shrub meadow (2)
- upper subalpine meadow (2)
- black spruce-lodgepole pine/willow/sedge (C8) forest (1)
- Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) forest (1)
- alpine heath meadow (1)
- rock glacier (unvegetated) (1)

LIFE HISTORY

Unlike most mustelid species, the least weasel does not undergo delayed implantation and as a result two or possibly more litters are born each year (Banfield 1974). The litter size ranges from three to ten with an average of five young. No dens or families of young have been recorded in Banff and Jasper.

The prey base of this canivore is limited by its diminutive stture. Comparable to a chipmunk in size, the Least weasel preys almost exclusively on mice, voles, shrews and insects (Soper 1964). The only record of predation by Least weasel is of an individual hunting mice at Vermilion Lakes in 1968 (Warden observation).

MINK *Mustela vison*

STATUS AND DISTRIBUTION

According to Banfield (1974) the mink "occupies all of Canada south of the treeline with the exception of Newfoundland, Anticosti Island, and the Queen Charlotte Islands".

In Alberta the mink occurs in wetlands throughout the coniferous region of northern Alberta as well as along the east slope of the Rocky Mountains (Soper 1964). It is uncommon in the southeastern prairie and the southern aspen parkland. Mink are present in the Cypress Hills in the southeast corner of the province.

Mink occur sparingly throughout the Rocky Mountains in low elevation wetlands. They are less common in the Main Ranges where suitable habitat is not as available.

In Waterton Lakes National Park mink are irregularly distributed in "modest numbers" (Nielsen 1973) and are common in Kananaskis Country wherever suitable aquatic habitats exist (Mill and Andersen 1980). Salt (1977) reported only one positive record of mink during the summer and fall of 1976 in Kananaskis Provincial Park. Mink are present in small numbers in Yoho National Park (McCrory and Blood 1978); there were 15 records between 1968 and 1977. They are apparently very rare in Kootenay National Park, there being only 3 recorded warden observations between 1953 and 1977.

Mink are locally common at low elevations in alluvial wetlands in Banff and Jasper. They are most abundant in the montane ecoregion, but also occur in some lower subalpine areas having suitable aquatic habitat.

In 46585 km-day of winter tracking in Banff and Jasper between 1975 and 1981, 117 mink tracks were recorded on 39 transects. There were 11 sightings and 14 random track observations during the same time period. In October of 1977, nine mink were captured and released during 222 trap nights at Vermillion Lakes and the Cave and Basin Swamp. Mink are equally as common in Jasper (.23 tracks/10km-day) as in Banff (.2 tracks/10km-day).

The majority of mink observations in Banff and Jasper have been in the Athabasca River and Bow River valleys and the lower reaches of their tributaries. Mink or their sign were seen in 23 of 64 watersheds censused between 1975 and 1981. From winter tracking, random observations and live trapping, mink are most common in the following watersheds in Banff (in decreasing order of importance): lower Bow River, Alexandra River and middle Bow River; and Jasper: lower Athabasca River, Miette River, middle Athabasca River, lower Maligne River, upper Athabasca River and Meadow Creek. Mink appear to be more widespread in Jasper than Banff; they were recorded in 14 of 33 watersheds (42%) in Jasper and 3 of 26 (12%) in Banff, between 1976 and 1980.

HABITAT

Mink are aquatic mammals which require wetlands or slow-moving streams with fish and other prey species. Soper (1976) commented of mink in Jasper that "Typical haunts... are in and along rivers, marshy ponds and lakes, muskeg waterways, and sluggish creeks and lowlands". During this project mink occurred in all these habitats, being commonest in montane wetlands at Vermilion Lakes and sedgy braided stream channels of the Alexandra River.

From winter tracking data, mink are most common in the montane (1.2 tracks/10km-day), followed by the lower subalpine (0.5 tracks/10km-day) and the upper subalpine (0.4 tracks/10km-day). Their elevational range is from 1080 to 2160 meters. The upper limit of elevation is much higher than reported from other areas in the Rockies. For example, mink in Waterton range to 1804 meters (Nielsen 1973). Our highest elevation is at Amethyst Lakes where an abundance of small rodents and rainbow trout

supports a small population of mink. This area is the only place in Banff and Jasper where mink occur commonly above the lower subalpine ecoregion.

Favored habitats of mink in Banff and Jasper, based on winter tracking data, are floodplain lakes with shorelines of sedge and high shrubs (eg. Vermilion Lakes and Pocahontas Ponds), braided stream channels with herb mat or sedge shorelines, (eg. Alexandra River and lower Athabasca River), floodplains with tall shrubs and sedge hummocks (eg. the Miette River near Geikie and the Jacques Creek fan in the lower Athabasca River valley). Mink were seen in other locales which did not have any of the above characteristics; for example mink occur along the lower Maligne River, where tracks were seen at various points up to Medicine Lake. The river is boulder-strewn, narrow, fast and surrounded by heavy pine-spruce forests, but apparently is sufficiently deep to support enough overwintering fish to sustain a mink population.

Elsewhere in the Rocky Mountains mink appear to occur in similar habitats, the common denominator being low elevations and proximity to water. Mink in Waterton prefer coniferous forest adjacent sluggish streams, lakes and ponds in the montane ecoregion, and swampy bottomlands, muskeg and beaver ponds in the Prairie-Parkland ecoregion (Nielsen 1973). In Yoho mink "show an affinity for rivers, lakes and riparian habitats, primarily at low elevations" (McCrory and Blood 1978).

LIFE HISTORY

Mink mate in spring (March or April) with litters being born six to ten weeks later (Soper 1970). Average litter size according to Banfield (1974) is 5 (2 to 10). Young mink were seen only three times in Banff and Jasper between 1945 and 1980. Average litter size from these sightings is 3.7 (2 to 5). Two adults were seen with the young on one occasion.

Mink are nocturnal creatures. This, combined with generally low densities of mink in Banff and Jasper, limits the number of observations relating to mink predation. Between 1945 and 1981, only five observations of predation by mink were reported. Prey items were fish, mallard, dipper, and small rodent (Warden files). Other prey items likely to be used by mink in Banff and Jasper are muskrat, varying hare, frogs and insects. Male mink are considerably larger than females and tend to feed upon larger prey such as muskrat and hare (Banfield 1974). The home range of male mink is larger than that of the female (Banfield 1974). As a result mink tracks may at times be encountered in atypical habitats distant from a waterbody.

Predators of the mink are probably few, given its aquatic lifestyle, but mink straying away from waterways at times will succumb to predators. A coyote caught and killed a mink in pine forest near Johnson Lake in November 1972. This is the only recorded instance of predation on mink in Banff or Jasper since 1945.

MANAGEMENT CONSIDERATIONS

Suitable habitat for mink is limited in Banff and Jasper. Montane wetlands, in particular, are important and should be protected. Artificial changes to drainage patterns in the Bow and Athabasca watersheds should be minimized since wetland productivity is dependent on a natural water regime.

Five mink, all from the Vermilion Lakes area, have been killed by vehicles since 1964 in Banff National Park. There have been no reports of mink fatalities on the highways or railways of Jasper.

WOLVERINE *Gulo gulo* **WOLV**

STATUS AND DISTRIBUTION

The wolverine is present at low densities over most of its range in Canada, which includes the boreal forest from Labrador to Alaska, the western mountains, and the arctic tundra. The most stable populations occur in mountainous areas of Alberta, British Columbia, and the Yukon Territories, and in remote or sparsely populated areas such as the Northwest Territories and northern prairie provinces. It is not found in the prairie grain belt, and is extirpated from most of the aspen parkland region of the prairie provinces, as well as from southern Ontario and Quebec and the maritimes (Banfield 1974).

In Alberta, the wolverine has been extirpated over much of its historic range (Soper 1964). Formerly occuring in all coniferous territory of the province, south through the aspen parklands and the Rocky Mountains, it is now found in significant numbers only in the Rocky Mountains, the Clear Hills and in isolated portions of the Peace River district (Holbrow 1976).

Wolverine are well represented in the Rocky Mountains being perhaps less common in the south. Nielsen (1973) states that this species "is rare and has a scattered distribution" on Waterton Lakes National Park. Its status is considerd "reasonably secure" in Kananaskis Country (Mill and Andersen 1980) despite harvest by fur trappers. Salt (1977) reported that wolverine occur in small numbers in remote, upper elevations of Kananaskis Provincial Park.

Wolverines are especially common along the west slope of the Rockies. Cockerton and Herrero (1973) report that "fresh tracks were observed almost daily" in Mt. Assiniboine Provincial Park during the spring of 1972/73. Wardens in Kootenay National Park recorded 58 wolverine sightings between 1952 and 1977. McCrory and Blood (1978) wrote that "Wolverine appear to occur in every valley in the park" and 52 sightings were reported in Yoho between 1951 and 1977.

The wolverine is a widespread and relatively common resident of both Banff (Figure 3.35) and Jasper National Parks. Wolverine tracks were recorded 253 times on 140 transects out of 46585 km-day of winter tracking. The wolverine is more common in Banff (.63 tracks/10km-day) than Jasper (.41 tracks/10km-day). There were 81 sightings reported in Banff (52) and Jasper (29) between 1976 and 1980 (Warden files, inventory files).

The wolverine has been recorded in most watersheds (52 of 64) censused, being slightly more common along the western half of both parks (Figure 3.35). Important watersheds, based on winter tracking, are: Johnston Creek, Southesk River, Baker Creek, Healy Creek, Bryant Creek, Clearwater River, and middle Bow River. Important watersheds for wolverine, based on warden files, include the Smoky River, Poboktan Creek and Sunwapta River watersheds.

HABITAT

In Banff and Jasper wolverine are most common in Engelmann spruce-subalpine fir forests of the subalpine ecoregion, though they have been recorded in a wide variety of habitats ranging form 1080 to 2800 meters elevation.

Based on ecosites in which wolverine tracks were recorded on winter tracking transects, the average number of tracks/10km-day in each ecoregion is:

lower subalpine (.66)
upper subalpine (.64)
alpine (.21)
montane (.07)

Alpine areas are probably used to a slightly greater extent than shown by these data, as tracks are frequently obscured by wind there. Elsewhere in the Rocky Mountains wolverine exhibit similar elevational preferences. In Yoho National Park 58% of wolverine observations were above 1525 m elevation, and 20% above 2134 m. Most detected wolverine activity in Mount Assinaboine Provincial Park occurred in the subalpine between 1970 and 2295 meters. In Waterton Lakes National Park they occur from 1380 to 2620 meters with most activity in the subalpine ecoregion.

The following habitats were used most frequently by wolverine in Banff and Jasper (# tracks/10km-day in decreasing order):

lodgepole pine-dominated burn (1.73)
stream channel (1.45)
Engelmann spruce-subalpine fir open forest (0.90)
subalpine shrub meadow (0.88)
Engelmann spruce-subalpine fir forest (0.66)
lodgepole pine-spruce forest (0.54)

Stream channels are used largely as travel routes. Open pine burns are not a widespread habitat in Banff or Jasper and are ranked high on the basis of 14 tracks only. Other habitats that appear to be important to wolverine, based on 145 random observations, are alpine tundra (11) and shrubby avalanche slopes (6). These are probably more important as summer or spring habitats when travel is easier in the alpine and avalanche-killed ungulates are exposed by snowmelt.

Alpine tundra, ribbon forests of subalpine larch, whitebark pine and alpine fir, and slide paths are preferred wolverine habitat in Yoho National Park (McCrory and Blood 1978). Wolverines were most active in Mount Assiniboine Provincial Park in spruce-fir-larch woods or open subalpine glades and meadows, although tracks were "frequently seen well above timberline, traversing mountain passes or high open slopes" (Cockerton and Herrero 1973). Rausch and Pearson (1972) suggest that wolverines may require high alpine snow patches during the heat of summer to prevent or ease thermal stress.

LIFE HISTORY

The Wolverine is an opportunistic hunter/scavenger that may occasionally prey upon large mammals under favorable conditions (Rausch and Pearson 1972).

Of 45 wolverine sightings related to feeding, 18 (49%) involved carrion (10 elk, 6 moose, 1 Bighorn sheep, 1 fox) and 10 involved garbage. In Mount Assiniboine Provincial Park (Cockerton and Herrero 1973) a wolverine remained feeding on the same moose carcass for almost a month. Carrion is an important food source, especially in winter. Two records of carrion-feeding involved a moose and sheep killed by avalanches.

There are only two records of wolverines successfully preying on ungulates in Banff and Jasper, one of a female deer and another of a yearling elk. Both of these were during mid-winter. Wolverines were observed stalking sheep on 4 occasions in Banff, and twice in Jasper. N. Mackenzie (pers. comm. in Holbrow 1976) believes that wolverine predation on bighorn sheep is fairly common. There are two records of attempted predation by wolverine on deer and one on a cow caribou. Cockerton and Herrero (1973) observed no predation by wolverine on large mammals in Mount Assiniboine Provincial Park. McCrory and Blood (1978) noted one attempt at predation on mountain goats in Yoho National Park in 1976.

Small to medium-sized mammals and birds probably make most of the wolverine's diet. Predation or attempted predation by wolverines on spruce grouse, ptarmigan, ground squirrel (sp.), marmot (2), red squirrel and coyote have been reported in Banff and Jasper and probably represent only part of this opportunistic species' diet. Rausch (1959) also includes porcupine, voles (*Microtus* and *Clethrionomys*), Varying hare, Black-billed Magpie and fish in the diet of the Alaska wolverine. McCrory and Blood (1978) describe a wolverine chasing two porcupines in Yoho National Park.

Predation on wolverines is apparently rare. On 13 January 1980 near the Panther River a partly-eaten wolverine carcass was found beside an elk carcass surrounded by wolf tracks (JLK). Boles (1977) reported a number of cases of wolf predation on wolverine in other areas.

There is a record of a wolverine attacking a coyote in the lower Spray River watershed of Banff (Warden observation). In Yoho National Park McCrory and Blood (1978) reported 7 coyotes circling a wolverine, while in Kootenay National Park a warden record describes a wolverine fighting two coyotes. It is difficult to determine whether these observations were related to attempted predation or to competition for food.

The wolverine is generally a solitary animal (Koehler et al. 1979, Banfield 1974), although Pulliainen (1968) reported that male wolverines visit den sites and may play a role in rearing the young. Observations from Banff and Jasper indicate that wolverines are primarily solitary travellers (89% of 372 wolverine sightings between the years 1945 and 1980 were of lone animals). Pairs of wolverines, including mated pairs and females with single young, were seen 27 times, while three animals were seen together 15 times. In Yoho National Park only 4 of 78 wolverine sightings or track records involved two animals (McCrory and Blood 1978). During the springs of 1972 and 1973, when "fresh tracks were observed almost daily", Cockerton and Herrero (1973) wolverines always travelled alone in Mount Assiniboine Provincial Park.

Wolverines breed in late spring and early summer (Wright and Rausch 1955, Pulliainen 1968, Rausch and Pearson 1972). Wolverines have not been observed mating in Banff or Jasper. Young are born in January, February, March and April, usually in dens dug into the snow. The single observation of a birth and den of wolverine in our area was in May 1961 (exact date unspecified) near the Peyto Lake viewpoint in the upper Bow valley of Banff (Warden record). Rausch and Pearson (1972) report litter sizes of from 2 to 5 (average 3.5) of Alaskan wolverine. There are five records of female wolverine with single young in Banff and Jasper since 1945, all between 31 August and 1 November. On 31 August 1958 a female wolverine chased a fisherman away from its young (Warden record). The cubs remain with the female during their first winter and disperse in the spring.

"The wolverine appears to require large ranges and some form of territorialism, the sizes of which are almost totally linked to the availability of food" (Holbrow 1976). Although no data are available regarding home range size in Banff and Jasper, an individual wolverine was tracked for 42 km from Athabasca Pass along the Whirlpool River to highway 93A on 12-14 January 1979 (JLK). Wolverines in the Rocky Mountains of Montana require ranges of up to 963 km^2 (Hornocker pers. comm.). Wolverines in Banff and Jasper travel along ski and snowmobile trails, fire roads, and frozen stream channels extensively. These are probably major factors influencing home range size and shape.

During winter, wolverines dig temporary snow beds which in Banff and Jasper were usually found under conifer roots which were easily accessible and protected from cave-ins. Seven beds were found in the Lake Louise area (Fig. 7 in Fitzmartyn and Holroyd 1978).

MANAGEMENT CONSIDERATIONS

Wolverines are attracted to refuse pits or poorly-stored garbage. This food source is unhealthy and dangerous, and wolverines attracted to low elevations by garbage are more likely to be killed on highways or railways, or by large predators.

Wolverines are relatively immune to road and railway mortality when they remain in their natural habitats which are usually remote from major roads. Three instances of highway and five of railway mortality have been recorded since 1945 in Banff and Jasper. It is possible that those wolverines killed were attracted to train or road-killed ungulates or to garbage.

Porcupines and wolverines have parallel distributions in Banff and Jasper (Figure 3.35), both being among the few winter inhabitants of deep snow areas in the upper subalpine ecoregion. The porcupine occurred in 15% of wolverine stomachs in an Alaskan wolverine study (Rausch and Pearson 1972). In remote, deep snow areas such as the Smoky River watershed of northwestern Jasper where porcupines and wolverines both are common, the porcupine is the only readily-available winter food source for wolverine. As such, destruction of porcupines should no longer be permitted.

In light of the range reductions and population declines that have taken place in the last century (Van Zyll de Jong 1975, Holbrow 1976) remote areas in the Rocky Mountains are among the last remaining wolverine strongholds south of the 60th parallel. National parks such as Banff and Jasper which still possess large areas of undisturbed land are thus sanctuaries for wolverines in the strongest sense of the word. Every effort should be made to retain large areas of land under wilderness classification to provide the space needed by wolverine for survival.

AMERICAN BADGER *Taxidea taxus* AMBA

STATUS AND DISTRIBUTION

The badger occurs in the three prairie provinces, ranging through the aspen parkland belt to as far north as the North Saskatchewan River in Alberta (Soper 1964). It is also found in the mountain valleys of southeastern British Columbia. The badger was at one time plentiful throughout the western prairies. With increased settlement and agriculture its numbers have dwindled, in part due to extermination by farmers and ranchers.

In southwestern Alberta, including Banff and Waterton Lakes National Parks, scattered populations of badger occur along the foothills and Front Ranges of the Rocky Mountains. In Waterton the badger occurs in moderate numbers in limited areas of suitable lowland habitat (Nielsen 1973). Salt (1977) found no evidence of badgers during an inventory of Kananaskis Provincial Park. They occur intermittently in the fur harvest returns of 11 Kananaskis Country trapping areas (Mill and Andersen 1980). The badger is hypothetical in Yoho National Park (McCrory and Blood 1978). Only four badgers, one a roadkill, were recorded by the warden service in Kootenay National Park between 1951 and 1978.

No recorded observations of badgers, historic or recent, are available from Jasper National Park. Banff National Park the badger is relatively uncommon, occurring primarily in the Cascade valley and to a lesser extent in other southern watersheds. Between 1975 and 1981, 28 badger sightings have been recorded in Banff (Warden files, Inventory files). Of this total 22 were in the middle Cascade River watershed. There are two records each from the Panther and Healy watersheds and single observations from the Bryant Creek and lower Spray River watersheds. Badger diggings were recorded in the middle Cascade River and lower Red Deer River watersheds.

Badgers were formerly more widespread than they are now in Banff. Green noted that "badger are often seen in the park about meadows and semi-open forest where ground squirrels abound". Sites where badger were most commonly seen were at the airfield and north along the Trans Canada highway between the Banff townsite and Redearth Creek. Cowan (1943) considered the badger widely distributed but not abundant, being seen at Hillsdale meadows,mi 15 along the Spray River, and at Allenby Pass. Clarke (1940) saw badgers at Scotch Camp and Stony Creek during his wildlife investigations. Hatter (1944) reports seeing badger diggings above and across the river from Scotch Camp on the Red Deer River in 1945.

Banfield (1958) said the range of the badger in Banff was restricted to grassland areas in the river valleys of the southeastern part of the park, including the Red Deer

River, Panther River, Cascade fire road, and Bow River valleys. He reported badger observations at Hillsdale, Bankhead and Flints Park.

Banff Park wardens recorded 48 observations totalling 76 badgers from 1944 to 1975. Nearly half of these observations were from the Bow valley, primarily along roadsides and disturbed grasslands near the townsite. Six sightings were along the highways between 5mi bridge and Lake Louise between 1948 and 1956. Since 1959 only one badger, a highway mortality in 1975, has been reported from the Bow valley.

HABITAT

Typical American badger habitat includes semi-arid plains and both long and short grass prairie (Soper 1964). In the foothills of Waterton Lakes National Park American badgers prefer open prairie, brushy bottomlands and aspen groves (Nielsen 1973). In the Kananaskis and Highwood areas, American badgers appear to be restricted mainly to valley bottoms, although burrows have been seen at Ricketts Pass (H. Carr pers. comm. in Mill and Andersen 1980).

In Banff, badgers occur from 1400 to about 2400 metres elevation. Of 26 sightings since 1976 for which elevation was recorded, 9 were montane, 19 were lower subalpine, 5 were upper subalpine and 2 were alpine. These data contrast markedly with earlier sightings. Of 40 badger sightings between the years 1945 and 1960, 22 were in the montane ecoregion.

Badgers occupy open habitats ranging from montane grassland through subalpine shrub meadows and avalanche slopes to alpine herb meadows. In the Cascade valley, where most recent badger sightings have been, there are numerous fire-successional open forests and dry grasslands. Columbian ground squirrels are abundant in these habitats.

Three badger burrows were recorded in Banff between 1976 and 1980, one each from the middle Cascade River, Panther River and lower Red Deer River watersheds. All were located in ecosites of glacial till on well-drained southwest-facing slopes. Two were on grassland slopes while the third was in an open lodgepole pine forest with a grassy understory.

LIFE HISTORY

The badger is known for its burrowing abilities which it uses to capture its prey, escape predation and construct dens.

The badger's diet includes ground squirrels, pocket gophers, mice, birds' eggs and insects (Banfield 1974). In Banff badgers have been seen preying upon Columbian ground squirrels on six occasions since 1945; these probably comprise the major prey item in this area.

Mating occurs in August or September and the young are not born until the following spring (Banfield 1974). The number of young per litter varies from one to five (Soper 1964). In Banff the average litter size of American badgers (n=6) is 3.4 with a range of 2 to 4.

The badger is rarely seen, even in areas where it is abundant because it is nocturnal.

MANAGEMENT CONSIDERATIONS

The lack of recent sightings in the montane ecoregion of the Bow valley is probably largely an effect of human disturbance. There were three recorded cases of badger being killed in collisions with vehicles between 1945 and 1959, one being a female with two young. The only badger recorded in the Bow River valley since 1960 was a roadkill, and this represents known mortality only. It is likely that other badgers

were killed or wounded on the roadways. Assuming that badgers have existed historically at low numbers in the Rocky Mountains, even limited road mortality may have been a major factor in their decline and ultimate disappearance from the Bow valley.

Loss of open grassland or scrubland as a result of fire suppression and forest succession may have decreased potential habitat for badgers in Banff.

RIVER OTTER *Lontra canadensis*

STATUS AND DISTRIBUTION

The river otter is widely, but sparsely, distributed across Canada, except in the northern arctic tundra and the great plains (Banfield 1974).

According to Soper (1964) the otter was never common in Alberta and its range has been greatly reduced west and north of the aspen parkland belt. He states further that otters are scarce in the Rocky Mountains. According to Nielsen (1973) the river otter is one of the rarest mammals in Waterton Lakes National Park, with only three recorded observations since 1959. Jalkotzy (1980) interviewed long-time residents of the Kananaskis area south and east of Banff and found that otters have been rare in that area in recent history. River otters were not observed by McCrory and Blood (1978) during an inventory of Yoho National Park. There have been no warden reports of otters in Kootenay National Park since records were first kept in 1951.

River otters are very rare and probably extirpated in Banff and Jasper. No otters or otter sign were observed by inventory staff in either Banff or Jasper during the course of the inventory. The last otter sighting in Banff was at Vermilion Lakes in 1977. In Jasper the last otter seen was on the Whirlpool River near the confluence of Simon Creek, also in 1977 (Warden files). These are the only records from Banff and Jasper National Parks since 1976.

River otters have never been abundant in the Rocky Mountains. Of the early explorers, only Henday in 1754 and Hector of the Palliser expedition (1858-1860) mentioned otters (Jalkotzy 1980). These reports were from near the present site of Calgary and the Little Red Deer River in the foothills.

Early faunal investigations in Banff by Anderson (1938) and Clarke (1940, 1943) did not include the river otter in their findings. Warden H. Green reported an otter at 3rd Vermillion Lake in 1944. Another otter was reported in the upper Redearth Creek valley in 1951 by a park warden. Banfield (1958) was justified in calling the river otter "extremely scarce" in Banff National Park as the next otter sighting was 26 years later at Vermilion Lakes.

Soper (1970) considered otters to be historically very scarce in the Alberta Rockies. He reported that an undetermined number of otters was sighted or trapped near Henry House on the lower Athabasca River of Jasper in the early 1900's. Soper collected an otter on the upper Wildhay River north of Jasper in the winter of 1913. He observed no otters or otter sign anywhere in Jasper during field studies from 1960 to 1963.

HABITAT

In Banff and Jasper otters inhabit or have inhabited floodplain and backwater areas of major river systems in the montane ecoregion. Localities include the Vermilion Lakes in Banff, Talbot Lake, Edna Lake and Pocahontas Ponds in Jasper. Most sightings were in marshy waterways also inhabited by American beaver and Muskrat. This habitat is of limited extent in both Banff and Jasper.

Liers (1951) describes the otter as a very mobile species, especially during the breeding season, and as such it requires large areas of suitable habitat. In west central Idaho, Melquist and Hornocker (1979) quote densities of one female and one to three pups per 15 km of watershed and one breeding male per 30 km. Jalkotzy (1980) summarized specific characteristics of most areas where river otter populations have been studied. They include:

* Waterways and marshes bordered by extensive forests.
* Waterways containing slow-moving pools with soft bottoms (eg. beaver ponds).
* High water quality with little turbidity or pollution.
* Year-round open water.

LIFE HISTORY

The otter is an amphibious mammal that relies on its strong swimming ability to capture its prey (Banfield 1974). At times it travels overland, particularly during the breeding season, when its trough-like trail through the snow is distinctive.

A number of field studies have suggested that slow-swimming forage fish are preferred species. Sheldon and Toll (1964) found that otters preyed chiefly on warmwater fishes such as yellow perch, white suckers and golden shiner in spite of high populations of lake, brown, and rainbow trout. Toweill (1974) found members of the trout family to be an important winter food of Oregon otters. However, these were thought to represent carrion or weak spawners.

The reproductive potential of river otters is low due to delayed implantation and small litter size (Hamilton and Rodic 1964). Otters may be sexually mature at two years of age, however, Banfield (1974) claims that males are not successful breeders until they are six or seven years old. Young are born in January or February and mating of adults occors soon after the young are born (Banfield 1974).

MANAGEMENT CONSIDERATIONS

Two otters have been reported killed by motor vehicles on the Yellowhead Highway in Jasper, one in 1967 and another in 1969. Since the latter roadkill, only a single record of otter has been noted in Jasper. The two otter killed possibly represents only a portion of the total number lost in this manner. At the low population levels that apparently existed in the lower Athabasca valley, even limited mortality could have led to the extirpation of otters from this area. Reintroduction of the species should not be attempted unless this source of mortality is removed, since highway 16 and CNR railroad transect the only extensive area of potential river otter habitat in Jasper.

COUGAR *Felis concolor* **COUG**

STATUS AND DISTRIBUTION

Cougars have been sighted in every Canadian province except Prince Edward Island and Newfoundland (Nero and Wrigly 1977), but by far the most stable populations occur in the mountains of Alberta and British Columbia.

In Alberta, cougars occur in pockets of suitable habitat along the Rocky Mountains and their foothills. They are also occasionally sighted along wooded river bottoms in the Southern plains as far east as the Cypress Hills (Soper 1964). In Waterton Lakes National Park, cougars are present in moderate numbers (Nielsen 1973). Soper (1967) estimated a population of twelve cougars in this 203 squaremi park. Mill and Anderson (1980) state, "Cougars are not frequently encountered in Kananaskis Country, yet may be as well established as in any other part of their range in Alberta". Salt (1977) observed three

cougar tracks during the autumn of 1976 in Kananaskis Provincial Park. In Yoho National Park "the cougar has apparently never been more than a rare summer visitor to the west side of the park" (McCrory and Blood 1978). Ten cougar records were reported from 1970 to 1976. During the same period wardens recorded 26 cougar observations in Kootenay National Park where a resident population is known to be present.

Cougars were apparently present in the Rocky Mountains at the time of the earliest white explorers but they were confined to the area south of the Bow River along the eastern slopes. James Hector heard one screaming near Lake Louise in 1859 (Spry 1968). His Indian companions told him that cougars were more common in the foothills than in the mountains. The Earl of Southesk believed cougars to be commonest south of the Bow and saw no sign of them during his travels through what is now southern Jasper and northern Banff.

Millar (1915) said that cougars "... are rarely seen on the east side of the mountains but a few have been killed in the Rocky Mountains Park". In 1916 two were seen in the Clearwater Forest (Clarke 1942). A population eruption appears to have taken place in both Banff and Jasper during the 1930's and many cougars were killed in both parks (see below, Management History).

It is very difficult to accurately census cougars because of their wary nature and large home ranges. However, winter tracking data suggests that cougars are presently very rare in both Banff and Jasper. 17797 km-day of tracking in Jasper yielded only 2 cougar tracks while in Banff no cougar tracks were recorded in 28788 km-day. Trends in warden observations also reveal that cougar are relatively uncommon at the present time (Figure 3.37).

Of 28 cougar observations between 1975 and 1980, 17 (60%) were from Jasper. In both parks cougar are more abundant in the Front Ranges than the Main Ranges. Of the 28 cougar observations 27 were from Front Range valleys.

Watersheds in which cougar or their sign were recorded include (N=28); lower Athabasca River (5), lower Cascade River (3), lower Maligne River (2); upper Maligne River (2), lower Snake Indian River (2) and one each from lower North Saskatchewan River, Panther River, Spray River, Pipestone River, Whirlpool River, Moosehorn Creek, Fiddle River, lower Brazeau River, north fork of the Brazeau River, middle Athabasca River, and Nigel Creek.

Soper (1970) reviewed the historical records of cougar in Jasper National Park from the turn of the nineteenth century through the early 1960's. The first cougar recorded in Jasper was a male collected by the Warden Service in 1927. A northward extension of cougar approaching eruptive proportions then took place, culminating in the killing of 19 cougars in 1935-36 by the Warden Service. Since this time cougar populations have remained low (Clarke 1942, Cowan 1943, Flook 1956; Jasper warden files).

HABITAT

Cougar are most common at low elevations in major river valleys where ungulates concentrate and snow accumulation is low.

Between 1976 and 1980 there were 27 cougar observations for which habitat and elevation were recorded. Of these 14 were in the montane, 10 in the lower subalpine, 2 in the upper subalpine and one in the alpine. Elevational range is 1080 to 2600 m. Habitats in which cougar have been recorded include: mixed forest (8), closed lodgepole pine forest (6), Douglas-fir forest (5), montane grassland (2), montane spruce wetland (2), Engelmann spruce-subalpine fir forest (2), closed larch forest (1), sedge meadow (1) and alpine tundra (1). Mixed and Douglas-fir forests are of limited extent in both parks and are consequently more important to cougars, considering the large proportion of sightings in them, than if they were more extensive.

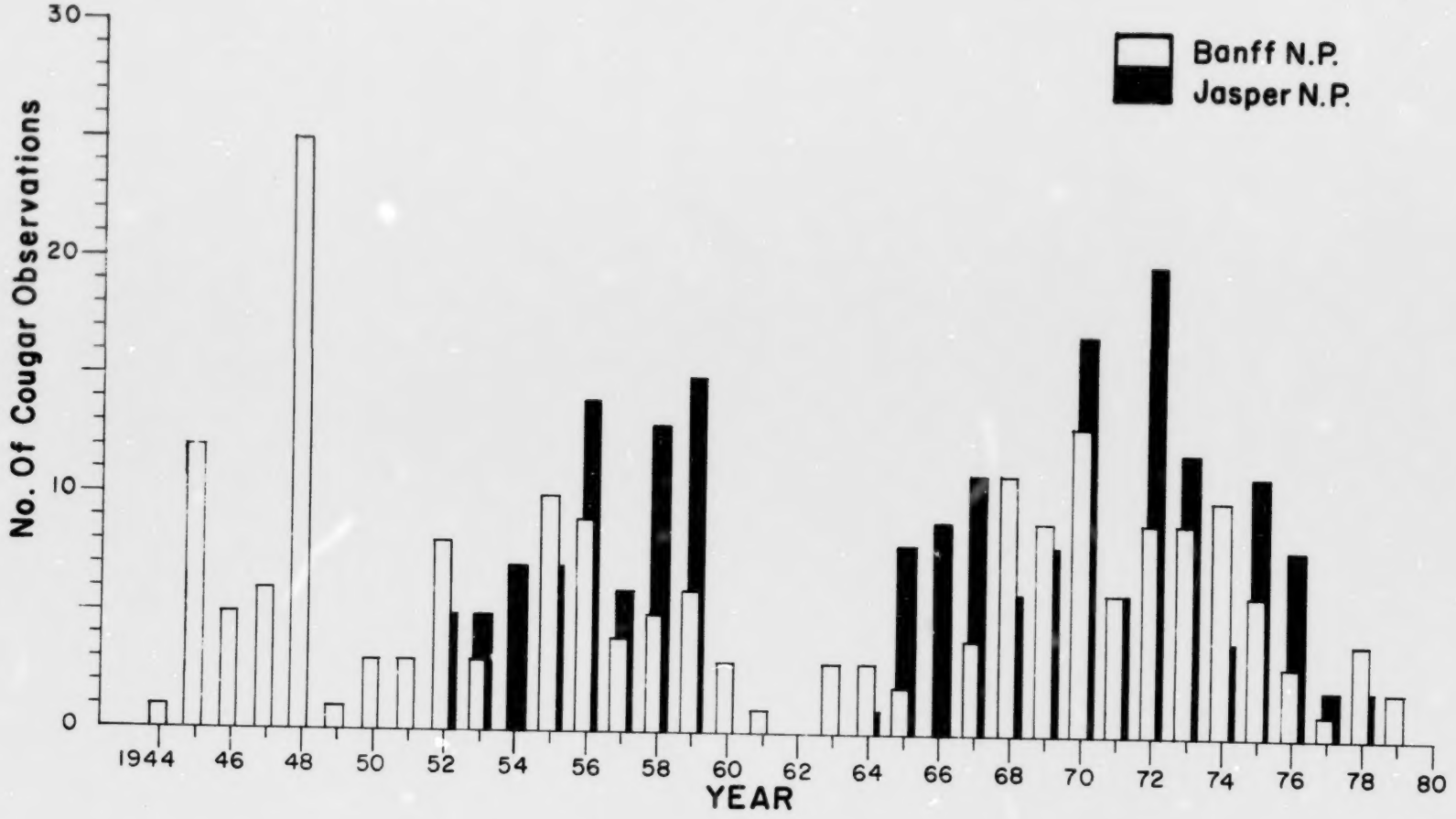


Figure 3.37. Numbers of cougar observations by year in Banff and Jasper, based on park wildlife cards 1944-1979.

A number of investigators have remarked upon the strong influence that prey species, particularly mule deer, have upon cougar distribution and habitat use. Russel (1978) wrote that "Probably the most consistent feature found in mountain lion habitat of western North America today is the presence of mule deer". In interior British Columbia preferred cougar habitats are rough, rocky, semi-open areas surrounding major winter deer ranges Spalding 1971).

To establish the potential importance of ecosites to cougars, we have used a weighted ranking system (see Methods, above) based on the habitat preferences of its major prey species: mule deer, elk and bighorn sheep. Elk and bighorn sheep are included because of the frequency with which they have been reported as prey in Banff and Jasper (Table 3.12).

The most important ecosites for cougar based on this approach include:
summer: alluvial fans and floodplains with open coniferous, mixed or deciduous forest; semi-open slopes or ridged terrain
(AT1, BK4, GA1, GT2, HD4, NY1, NY3, PT1, TA3)
winter: montane alluvial fans and semi-open slopes; ridged terrain with coniferous forest interspersed with grassland or aspen forest
(AT1, AT3, DV1, DV2, GT1, HD2, HD4, NY1, NY3, PT3, PT4, SB5, TA2, TA3)

LIFE HISTORY

The cougar is rarely seen, being usually nocturnal and solitary.

Mule deer, bighorn sheep, and elk are the primary prey species in Banff and Jasper (Table 3.12). Of special interest is the heavy use of bighorn sheep. Hornocker (1970) found evidence of only two cougar kills of bighorn sheep in four years in Idaho in spite of the availability of sheep. In the same area, the mountain goat was also of only minor importance as a prey item. In Banff goats appear to be preyed upon to almost the same extent as sheep although no goat predation has been recorded in Jasper. Moose predation is rare, as was also reported by Wolfe (1974) who feels that moose are too large to be killed by cougar except by chance.

Breeding takes place any time of the year and the gestation period is approximately three months. The average litter size is 2 to 4 (Banfield 1974). Average post-partum litter size in Banff and Jasper National Parks is 2 (n=9). The maximum number of kittens seen with a single adult is 3, on two occasions in Jasper.

MANAGEMENT CONSIDERATIONS

The Cougar is an important component of the fauna of Banff and Jasper for several reasons. As an effective year-round predator of ungulates the Cougar may help to buffer population fluctuations and cull unfit animals from the populations. Cougar predation on wintering game herds may redistribute use of winter range, thus preventing depletion of localized food sources (Spalding undated). Finally, the presence of Cougar symbolizes the wilderness character and ecological integrity of the Rocky Mountain environment.

Its consistent use of the montane, especially during the winter, regularly brings the Cougar into contact with man and his facilities. Seven instances of highway mortality and one of railroad mortality have been documented by the Banff warden service since 1945. In the same period one highway and five railroad mortalities have been reported from Jasper. These are minimum figures only, and other cases of mortality, especially on the railway, may not be reported. To reduce railway mortality trainkills should be reported promptly by railway officials, and immediately removed from the vicinity of the tracks. It is likely that many cases of railway mortality occur as a result of Cougar feeding on ungulates that have been killed or wounded by trains. For similar reasons, a regular patrol of highways for ungulate mortalities, and removal of carcasses may reduce highway

Table 3.12. Cougar ungulate prey (as recorded on Banff and Jasper warden wildlife cards, 1945 to 1976).

		SUMMER						WINTER						
Park	Species	M	F	YOY	YLY	UNK	Total	M	F	YOY	YLY	UNK	Total	Year-round total
BANFF	Mule deer	0	0	0	0	0(1)	**0(1)**	2	5	2	0	2(1)	**11(1)**	11(2)
	Elk	0	0	0	2	0	**2**	3	0	2	2	3	**8**	10
	Moose	0	0	0	0	0	**0**	0	0	0	1	0	**1**	1
	Bighorn sheep	0	0	1	0	2	**2**	1	3	0	0	0	**4**	7
	Mountain goat	0	0	2	0	0(2)	**2(2)**	1	0	0	0	0	**1**	3(2)
JASPER	Mule deer	0(1)	0(2)	0	0	0(1)	**0(4)**	0	0(3)	0	0	0(1)	**0(4)**	0(8)
	Elk	0	0	0	0	0	**0**	0	0	1	0	0	**1**	1
	Caribou	0	0	0	0	0	**0**	0	1	0	0	0	**1**	1
	Bighorn sheep	0	0	0	0	0	**0**	1(1)	4	0	1	2(2)	**8(3)**	8(3)
	Mountain goat	0	0	0	0	0	**0**	0	0	0	0	0	**0**	0

( )=unsucessful attempts.

mortality of Cougar and other scaveriging carnivores. Elimination, by fencing or other means, of railroad and highway ungulate mortality would also reduce Cougar mortality.

Cougar are occasionally seen in townsites, particularly in Jasper townsite where ten have been reported by wardens since 1952. Cougars were reported eight times in Banff townsite during the same period. Up to 28 Mule deer have been counted within the limits of Jasper townsite (January 1979), which may partly account for these cougar records.

There have been five reported cases of cougars killing domestic dogs in Banff and Jasper since 1945. In 1975 a female cougar in very poor condition was destroyed near the Jasper warden office after two attacks on dogs including one in which it broke a window. A short time later a female with two kittens began killing dogs in Jasper townsite and was destroyed, the kittens later being released near Willow Creek (Jasper warden files).

A total of 33 Cougar were reported killed by wardens between 1924 and 1936 in Banff and at least 50 were killed in Jasper before 1941 (Clarke 1941). Since 1960 at least four cougars have been destroyed due to aggressive behavior or proximity to human habitation. Under certain circumstances Cougars have been known to attack man (Spalding 1971). However, in light of their low population levels, every effort should be made to transport offending cougars to remote areas with suitable habitat rather than killing them.

Ultimately, the future of the cougar in these national parks may hinge upon the retention of extensive low-elevation wilderness. Proliferation of access roads and habitat loss have been shown to be detrimental to the cougar (Cahalone 1964, Wright 1968) and may account for the present rarity of cougar in Banff and Jasper. More than 7% of the highly important montane ecoregion has been developed in the Bow River valley (Holroyd and Markel unpub. data). The Cougar is a rare animal in Jasper and very rare in Banff; even low levels of unnatural mortality and minor habitat loss may reduce populations below critical levels. Cougar populations are probably maintained at present by dispersal from areas outside the parks.

CANADA LYNX *Lynx canadensis*

STATUS AND DISTRIBUTION

The lynx occurs throughout the boreal forest and aspen parkland of Canada, its abundance fluctuating in response to that of the varying hare which dominates its diet (Banfield 1974). Permanent lynx populations are absent from the northern arctic tundra, the prairies, the provinces of Prince Edward Island and New Brunswick and the coastal ranges of British Columbia, although extra limital occurrences have been recorded during periods of snowshow have scarcity. The present distribution of lynx has shifted northward from its former southern boundary because of development of southern areas (Van Zyll de Jong 1971).

In Alberta, the lynx's distribution coincides with the Cordilleran-Boreal region (Soper 1964). Lynx are occasionally seen in islands of forested land on the prairies, such as the Cypress Hills and Milk River canyon.

Lynx are found along the length of the Rocky Mountains, but are generally less common there than in the boreal forest. Nielsen (1973) and Soper (1967) consider it uncommon in Waterton Lakes National Park. In Glacier National Park, Montana the lynx is also scarce (Lechleitner 1955). Lynx are regularly trapped in Kananaskis Country (Mill and Andersen 1980) especially in the more mountainous western portions. Early winter tracking records suggest that lynx may be fairly common in Kananaskis Provincial Park (Salt 1977). In Yoho National Park lynx are relatively common and widely distributed. They are not common in Kootenay National Park, where wardens have recorded only 55 between 1952 and 1977.

Lynx were relatively scarce in Banff and Jasper from 1975 to 1980. Only 27 lynx tracks were recorded in 46585 km-day of winter tracking transects. A further 37 sightings and 22 lynx tracks were also recorded.

The lynx is more abundant in Jasper than Banff and there is evidence that this has been the case historically as well (Figure 3.38). Of the 86 lynx records mentioned above, 58 (67%) are from Jasper. They are widely distributed throughout both parks. Lynx or their sign have been seen in 34 of the 64 watersheds censused. The watersheds having the greatest number of lynx records between 1975 and 1980 (N=86) are: middle Bow River (7), Miette River (5), lower Athabasca River (5), middle Maligne River (5), Southesk River (4).

HABITAT

Because of the almost complete dependence of the lynx on the varying hare, the habitat requirements of these two species are essentially identical (L. Keith, University of Wisconsin, pers. comm.). Koehler et al. (1979) found that lynx were most active in young, dense lodgepole pine stands in which varying hares thrived. In Newfoundland, Saunders (1963) determined that lynx home ranges were concentrated within tracts of 10 to 20 year old forests.

During this inventory lynx were recorded in winter 78 times of which 23 records were in lodgepole pine-spruce forests, 11 in shrub meadows, 11 in Engelmann spruce-subalpine fir forest, 9 in Engelmann spruce-subalpine fir open forest, 5 each in white spruce forest, avalanche scrub and mixed poplar-conifer forest, 3 in lodgepole pine savannah forest, and 1 on a frozen lake surface. Habitat was not recorded for 5 observations.

During winter lynx tracks were seen at elevations ranging from 1080 to 2130 m. Lynx were recorded most often in the lower subalpine (58 of 78 records), while the montane (13) and upper subalpine (7) ecoregions received considerably less use. No lynx or lynx tracks were seen in the alpine.

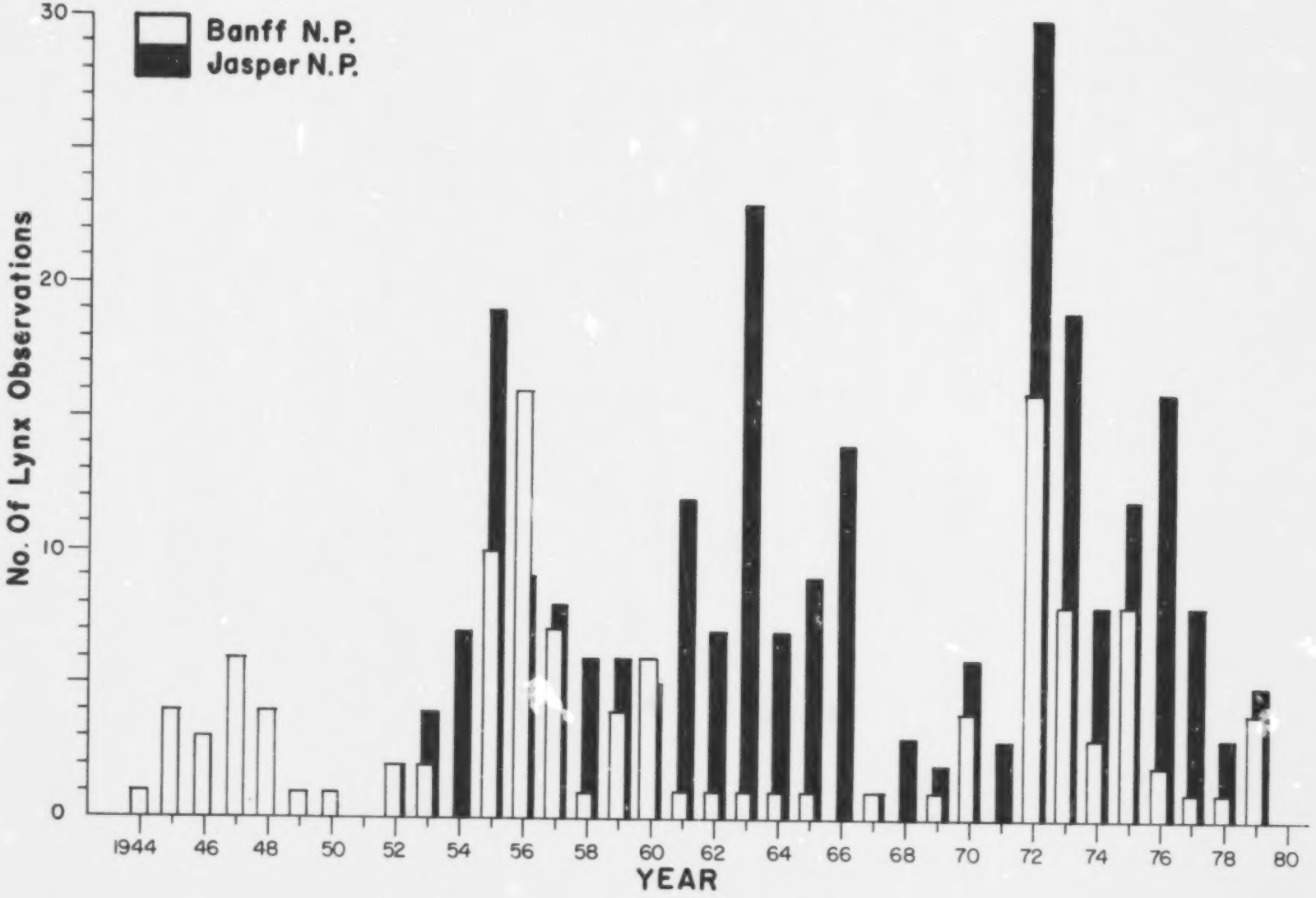


Figure 3.38. Numbers of lynx observations by year in Banff and Jasper, based on park wildlife cards 1944-1979.

Oertli and Stelfox (1975) detected highest use by lynx in lodgepole pine-spruce forest on alluvial fans in the Bow valley. Fitzmartyn and Holroyd (1978) regularly encountered lynx tracks in lodgepole pine/buffaloberry and birch/willow shrub meadows in the lower Pipestone valley. Carbyn (1972a) reported an abundance of lynx sign among aspen stands with shrubby understories along the lower end of Rock Creek in Jasper.

LIFE HISTORY

The varying hare is the major prey of the Canada lynx, so much so that lynx numbers regularly fluctuate in response to lows and highs in hare populations (Brand et al. 1976). Random warden obsevations provide the only long term data on lynx in Banff and Jasper (Figure 3.38). Although there are some biasing factors such as fluctuations in manpower and backcountry travel, it appears that, at least in Jasper, lynx numbers fluctuate with about a 9 year periodicity. The sparsity of sightings from 1961 to 1966 in Banff is at least partly an artifact of reduced warden input due to changed methods of filing observations (Perry Jacobsen, Banff warden service, pers. comm.).

A study in central Alberta showed the lynx's winter diet to be comprised of Varying hare (76%), Ruffed Grouse (9%), Red squirrel (3%), and carrion (10%) (Nellis et al. 1972). All the above prey are present in Banff and Jasper. Other prey species that have been reported and that are present in Banff or Jasper include Northern flying squirrel, Deer mouse, Masked shrew, Columbian ground squirrel, American beaver, deer and moose carrion, Gapper's red-backed vole, Meadow vole, chickadee, duck (sp.) and other lynx (Van Zyll de Jong 1966, Saunders 1963).

In Banff and Jasper there have been 25 instances of predation recorded since 1945. (Warden files). Of these five were of Varying hare. There were 16 instances of lynx feeding on carrion, partly because the likelihood of observing lynx at a stationary food source such as carrion is greater than a chance sighting of predation. Sources of carrion included train kills (5), avalanche kills (2), wolf kill (1), and unknown (8). Carrion species included elk (primarily train kills) (7), bear (2), moose (1), sheep (2) and unknown (4). Single cases of predation upon deer, sheep, and spruce grouse were also observed. Only one observation of a lynx feeding on garbage has been recorded. Carbyn (1974b) found a dead 5-day old elk calf that appeared to have been killed by a lynx.

Banfield (1974) reports litter sizes of from 2 to 3. There is only one litter per year. Lynx pregnancy rates and litter sizes decrease during periods of Varying hare scarcity (Brand and Keith 1979).

MANAGEMENT CONSIDERATIONS

The secretive nature and nocturnal hunting behavior of the lynx allow it to avoid most human harassment. On lands outside of the National Parks lynx are trapped intensively and in certain localities have been extirpated by trapping (Van Zyll de Jong 1971). Hence, the National Parks are essential sanctuaries for indisturbed lynx populations.

Fire control may indirectly contribute to lynx scarcity in Banff and Jasper. Varying hare are particularly abundant in post-fire successional forests (Grange 1965). Suppression of naturally occuring forest fires has steadily decreased the extent of this type of forest habitat in Banff and Jasper.

Because lynx depend heavily on Varying hares, any policy that causes Varying hares to become less abundant will ultimately decrease the potential of these parks to support lynx.

WOODLAND CARIBOU *Rangifer tarandus caribou* **CARI**

STATUS AND DISTRIBUTION

Woodland caribou occur in the boreal forest region from Newfoundland and Labrador west across Canada to B.C. and southern Yukon territory (Banfield 1974).

In Alberta Woodland caribou occur from the Siffleur and Cline River drainages north through Jasper and the Willmore Wilderness area to the foothills south and west of the Grande Prairie area, as well as north of the Grande Prairie area to the Northwest Territories border and east to near Cold Lake. Caribou populations have been declining steadily in the last 15 years from a provincial total of 7000 to 9000 in 1966 to a present population of around 3000 (Michael Bloomfield, Alberta Fish and Wildlife, pers. comm.).

There appears to be little difference between the distribution of caribou in Banff and Jasper today and their distribution in the nineteenth century, although their numbers have diminished. Neither James Hector nor the Earl of Southesk noted caribou in Banff in 1859, though both traversed areas in which they now occur (Spry 1967, Southesk 1875). The earliest reference to caribou in Banff was by the guide Jimmy Simpson who tracked a cow and yearling down the Siffleur from Clearwater Gap in 1902 (Cowan 1943). Simpson reported that around 1900 a band of Stoney hunters encountered a herd of caribou at Pipestone Pass and killed all but two.

In the Jasper region caribou were more common. David Douglas reported that caribou were "found in abundance in the mountains" of the Jasper area in 1827, and Henry Moberley, travelling north of the Athabasca River in 1855, said that "Bighorn and caribou were almost always in sight... We killed... many... caribou... " (Moberley and Cameron 1929). Loring observed caribou in the Athabasca and Smoky drainages and Hollister (1912) collected some at Moose Pass, at the head of the Snaring River. He was told by Lewis Swift that caribou were less plentiful in the Front Ranges than they had formerly been (Soper 1970).

Caribou occur in all the areas described by Clarke (1942) and Cowan (1943) but in somewhat reduced numbers. Any attempt to assess the degree to which caribou have decreased in the last century is hindered by the paucity of quantitative historical records and the difficulty of censusing so patchily-distributed and wide-ranging a species.

Only one small population of Woodland caribou now occurs in Banff. In 1974 it consisted of 11 animals (J.Rimmer). Since 1975 caribou were observed only twice in Banff by wildlife inventory staff and fourteen times by park staff. Of these sightings, twelve were along the Siffleur River, two along the Pipestone River, one along the upper Clearwater River and one in Dolomite Pass (Figure 3.39). The largest single observation was of 14 caribou. Records span the entire period from June to March. There are historical records in the upper North Saskatchewan and Castleguard valleys (Jacobson 1979).

Woodland caribou are well-distributed in Jasper (Figure 3.40) but, as elsewhere in their range, they appear to be undergoing a marked decline. Stelfox et al. (1974) estimated the total Jasper population at 360 to 875 between 1915 and 1960, and at 425 to 711 between 1960 and 1974. Park wardens estimate the present population at 130.

The largest population (30 to 60) frequents the Astoria River, Meadow Creek and Portal Creek area and wanders into Mt. Robson Provincial Park in B.C. Another large population (30 to 60) frequents the Blue Creek, Rock Creek, upper Snake Indian River, and Smoky River watersheds and adjacent parts of the Willmore. At least part of this population winters in the park but it is believed that some leave the park and winter in the foothills east of the Willmore (Bloomfield, pers. comm.) and males which wander out

Figure 3.39. Distribution of caribou observations in Banff, summer and winter.

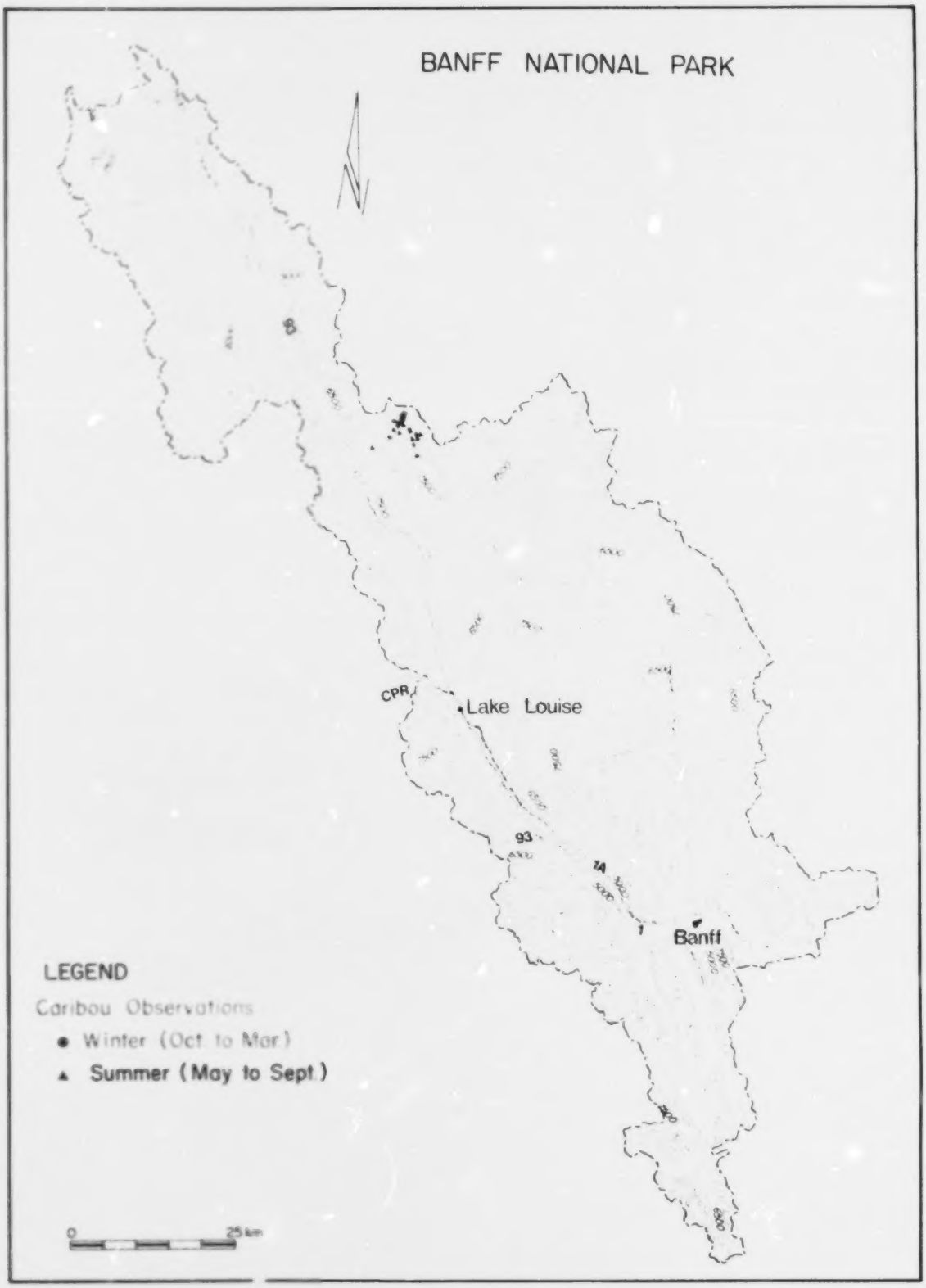
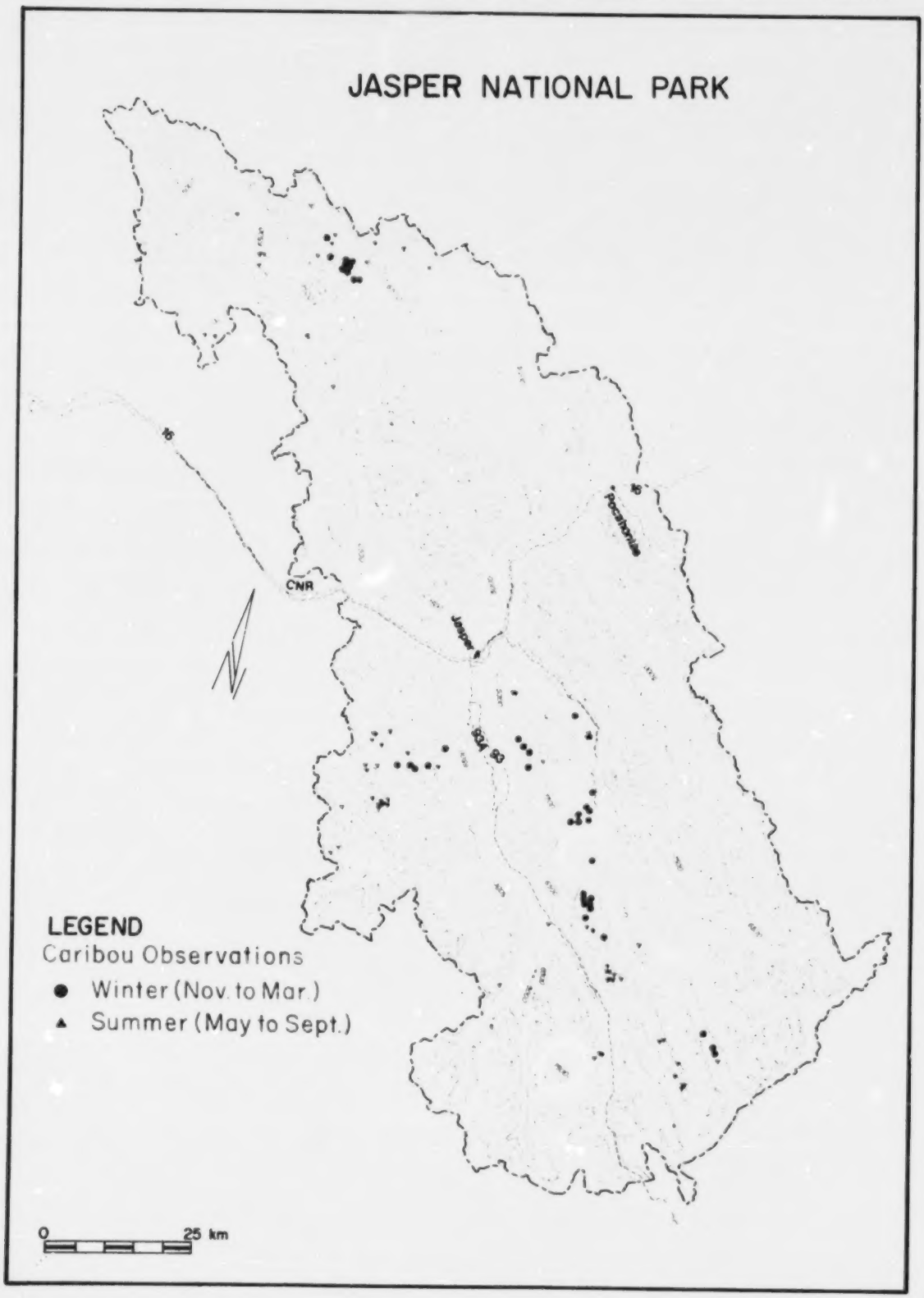


Figure 3.40. Distribution of caribou observations in Jasper, summer and winter.



of the park in autumn were killed by hunters (Jasper warden files) prior to 1981.

Elsewhere, caribou occur in the Sunwapta River and Athabasca River watersheds, in the Miette River and Snaring River watersheds, and a small population frequents the Maligne Range, wintering in the watersheds of the upper Maligne River and middle Maligne River. There have been 2 observations in the Moosehorn Creek and 1 in the lower Athabasca River valleys in the last 6 years.

Stelfox and Bindernagel (1978) consider the following locations to be important summer and rutting ranges for Woodland caribou in Jasper:

Tonquin valley
Maccarib Creek headwaters
Campus Creek headwaters
Watchtower Creek headwaters
Jeffery Creek headwaters
Evelyn Creek headwaters
Jonas Creek headwaters
Poboktan Creek headwaters
John-John Creek headwaters
Maligne Pass
Upper Snake Indian River
Blue Creek headwaters

HABITAT

Woodland caribou are primarily a species of the subalpine and alpine ecoregions. Since 1975 there have been only 2 sightings in the montane ecoregion. Pellet count densities in ecosites in which caribou pellets were found were 0 pellet groups/ha in the montane, 1.37/ha in the lower subalpine, 8.22/ha in the upper subalpine, and 13.73/ha in the alpine (Figure 3.111, Table 3.13, 3.14).

In summer caribou forage and bed frequently in the alpine ecoregion. Of 23 recorded sightings of caribou in the alpine since 1975, 22 were in June and July. Carbyn (1974b) observed bulls in alpine areas in summer in the Willow Creek and Rock Creek drainages and Stelfox (1978) also observed a peak in Woodland caribou use of the alpine in July and August.

Of the vegetation types in which moderate to high caribou summer pellet group densities were recorded, 50% were in the alpine ecoregion (Table 3.15). A further 36% were Engelmann spruce-subalpine fir forests, particularly those having open canopies and shrubby understories, and the remaining were shrubby willow meadows.

Of 30 caribou sightings since 1975, 5 were on subalpine avalanche slopes, although Stelfox et al. (1978) consider avalanche slopes to be unimportant to caribou. Generally, Woodland caribou prefer rolling till plains and inclined till slopes (70% of all ecosites in which moderate to high summer caribou pellet group densities were recorded). The presence of permanent snowfields and snow beds is highly important to Woodland caribou. Stelfox et al. (1978) demonstrated a marked correlation between summer Woodland caribou distribution and the distribution of permanent snowfields on the landscape. They felt that Woodland caribou in Jasper are existing under marginal climatic conditions in summer and that snowbeds allowed them to withstand summer heat.

In winter Woodland caribou spend proportionately more time in the alpine ecoregion than they do in the subalpine. Of the ecosites in which caribou tracks were observed on winter track transects, there was a density of 1.5 tracks/10km-day in the lower subalpine, 1.5 tracks/10km-day in the upper subalpine, and 6.5 tracks/10km-day in the alpine ecoregion. Closed forests are more important in winter than in summer (Table 3.16).

Figure 3.41. Habitat use by woodland caribou, based on pellet group densities.

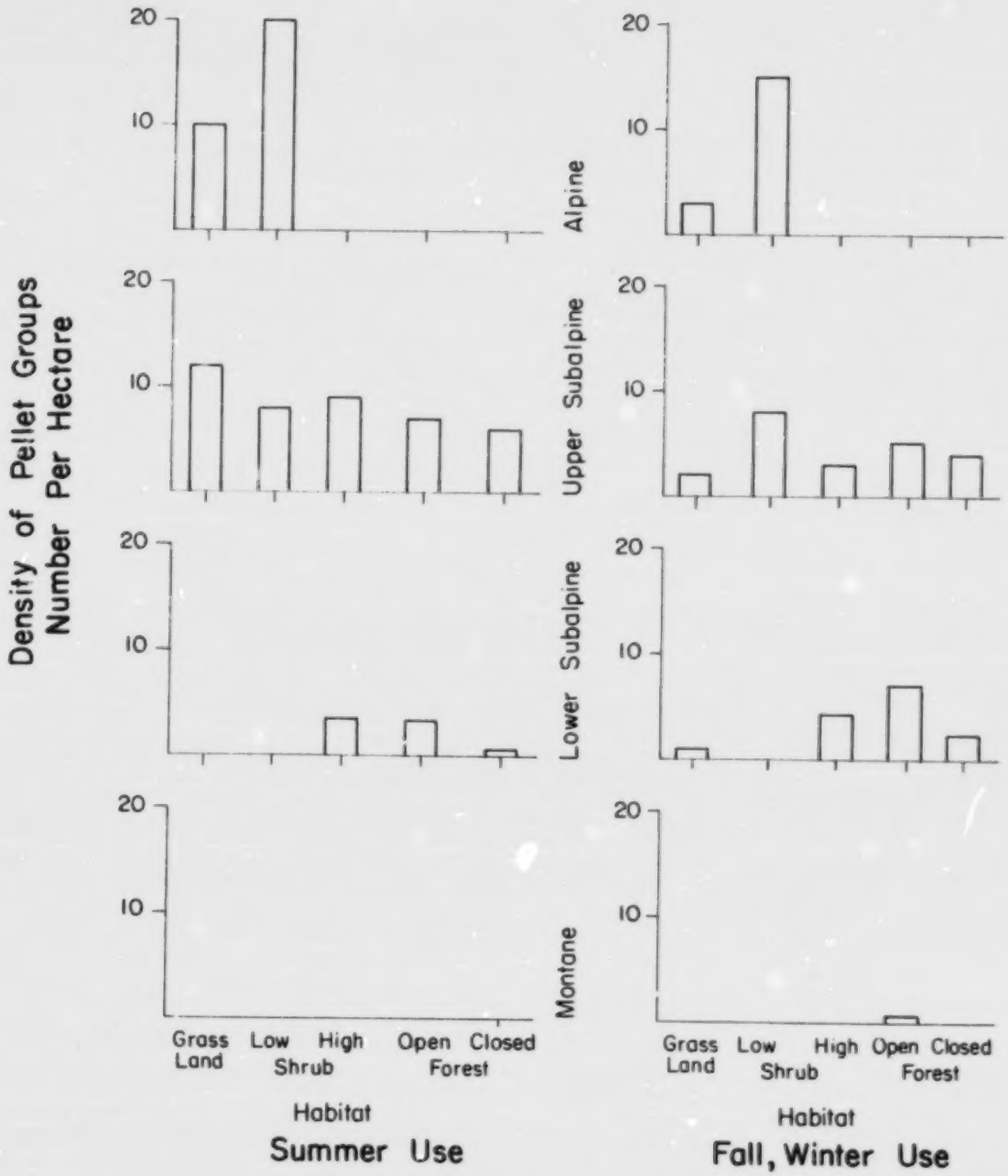


Table 3.13. Highly important spring and early summer ecosites for caribou.

Ecosite	Pellet groups/ ha	Ecoregion	Parent material	Vegetation
AZ1	160.0	upper subalpine	ice-contact drift	open spruce-fir forest and willow scrub
RO0	112.0	variable	rock	unvegetated
JN1	42.2	alpine	glacial till	heath
TR2	35.5	upper subalpine	glacial till	herb meadows
EF1	30.8	alpine	glacial till	heath
LV3	27.1	upper subalpine	glacial till	spruce-fir forest
WF2	24.2	upper subalpine	colluvium	avalanche shrubbery
EG4	18.3	upper subalpine	glacial till	open spruce-fir forest
CP1	14.3	upper subalpine	weathered rock	spruce-fir forest
SX3	14.3	upper subalpine	glacial till	willow scrub
SX1	14.1	upper subalpine	glacial till	herb meadows, heath
SX2	13.8	upper subalpine	glacial till	open spruce-fir forest
EN2	10.0	upper subalpine	colluvium	avalanche shrubbery

The importance of mature and over-mature lichen-producing forests to Woodland caribou for food, cover and shelter (Bloomfield 1980a, Edwards and Ritcey 1960) is reflected in the fact that 12 out of the 19 vegetation types in which moderate or high densities of winter caribou pellet groups were found are forested types (Table 3.16). Caribou use forested areas and forest edges during most of the winter, where they feed by cratering for ground vegetation as well as on tree lichens. Open forests in subalpine valleys and the bases of avalanche slopes are important as long as the snow is not too dense or crusted. When snow conditions are no longer favourable for cratering, Woodland caribou move into forested areas to feed on arboreal lichens or onto windswept alpine areas where ground vegetation is exposed.

Woodland caribou are well-adapted to snow, having both a large foot area and a low foot load (140 grams/sq. cm) (Telfer and Kelsall 1971). Stelfox et al. (1978) found that the average snow depth in areas frequented by caribou between September and May in Jasper was 67.1 cm., considerably deeper than for most other ungulates. Our data give a snow depth range of 11 to 65 cm., and an average of 43 cm, however we recorded only 209 tracks in 46,385 km-day, the majority of which were recorded on one field trip in northern Jasper when the average snow depth was 41 to 45 cm.

In general, Woodland caribou frequent areas of greater snow accumulation than other ungulates can, and move into areas of shallow snow or into dense forests in late winter when the snow becomes dense and crusted. Stelfox et al. (1974) reported that Jasper Woodland caribou occur most commonly on north and east exposures.

Table 3.14. Highly important late summer, autumn and winter ecosites for caribou.

Ecosite	Pellet groups/ha	Ecoregion	Parent material	Vegetation
ML3	100.0	lower subalpine	glacial till	spruce-whitebark pine forest
BZ2	60.0	lower subalpine	weathered rock	lodgepole pine forest
RO0	48.0	variable	rock	un-vegetated
LV3	32.9	upper subalpine	glacial till	spruce-fir forest
CA4	22.2	lower subalpine	glacial till	lodgepole pine forest
EF1	21.5	alpine	glacial till	heath
JN1	21.5	alpine	glacial till	heath
CV1	21.2	lower subalpine	glacial till	spruce-fir and pine forest
BY2	16.0	lower subalpine	glacial till	spruce-fir forest
LV2	15.2	upper subalpine	glacial till	open spruce-fir forest
HC1	13.7	lower subalpine	alluvium	spruce-fir forest and shrubby wetlands
SX1	11.9	upper subalpine	glacial till	herb meadows, heath
TR2	11.8	upper subalpine	glacial till	herb meadows
SX2	11.3	upper subalpine	glacial till	open spruce-fir forest

In May and early June Woodland caribou move temporarily onto lower subalpine deltas and alluvial areas, at least in parts of Banff and Jasper, where they feed on newly emerging sedges (Stelfox et al. 1978). At this season caribou are regularly observed at the head of Medicine Lake and less regularly on Beauty Creek flats (Jasper warden records).

LIFE HISTORY

Food habits

Stelfox et al. (1978) conducted a detailed investigation into the range ecology of Woodland caribou in Jasper to which the reader is referred. Caribou diet was found to vary markedly throughout the year but graminoids, lichens, *Equisetum* species, and forbs were generally the most important plants on a year-round basis (Table 3.17). The lush wet herb meadows of the Tonquin valley and the unique abundance of *Cladina* and *Peltigera* species in the Blue Creek valley account in large part for their importance to Woodland caribou, since they provide a wealth of preferred forage species.

Lichens become highly important in winter when both ground and arboreal lichens are used. Crater analyses in the Maligne valley by Stelfox et al. (ibid.) indicated that the most important lichens were *Cladina arbuscula, Peltigera apthosa, Alectoria glabra,* and *Cetraria pinastri.*

Table 3.15. Highly important spring and early summer vegetation types for caribou.

Description	*Vegetation type*
White dryas-sedge meadow	H15
Mountain avens-golden sedge tundra	H4
Mountain avens-snow willow-moss campion tundra	H1
Heather-everlasting heath meadow	L5
Heather-mountain avens-snow willow heath meadow	L4
Sedge-pussytoes tundra	H2
Fleabane-valerian herb meadow	H16
Subalpine fir avalanche complex	S2
Engelmann spruce-subalpine fir/rock willow open forest	O14
Engelmann spruce-subalpine fir/Labrador tea crowberry forest	C30
Engelmann spruce-subalpine fir/heather open forest	O10
Engelmann spruce-subalpine fir/willow open forest	O8
Spruce/willow/sedge bog forest	O6
Willow/herb cinquefoil shrub meadow	S8
Dwarf birch-willow-shrubby cinquefoil shrub meadow	S10

Rut

The breeding season of Woodland caribou is shorter than that of any other deer, with most breeding taking place during a one-week period in the middle or end of October (Bergerud 1978) in Newfoundland; however the only record of rutting activity in Jasper is 13 September 1960 on Campus Creek (Jasper warden records). Bergerud considers the gestation period of Woodland caribou to be 227 to 229 days; births were observed in the Blue Creek watershed on 22 May 1957 and 28 May 1959, placing the rut in the first two weeks of October in Jasper. Rutting ranges are itemized above (Status and distribution).

Calving

Bergerud (1978) considers calving ranges to be traditional areas; consequently their identification and protection from disturbance are critical concerns. Calving occurs in late May in Jasper, at which time human use of the upper subalpine and alpine is low.

Calves have been observed being born in the Topaz valley and on the slopes of the Ancient Wall and it can be assumed that the entire headwaters region of Blue Creek is important calving habitat. Calves with cows have been observed in May and June in the following areas:

Mount Edith Cavell meadows
Bald Hills meadows
Tonquin valley
Eremite Pass
Byng and Snake Indian Passes
above Hoodoos Cabin (upper Snake Indian River)
Carcajou Creek and Mount Jessie

Lick use

Caribou have been recorded at mineral licks, usually mud licks (Maps RLM3 and RLM4) between 6 June and 22 October but there are insufficient data to assess peak periods of use. Ten Woodland caribou were licking road salt on the Maligne Lake road

Table 3.16. Highly important late summer, autumn and winter vegetation types for caribou.

Spruce/willow/sedge bog forest	O6
Engelmann spruce–subalpine fir/wildrye open forest	O18
Engelmann spruce–subalpine fir/heather open forest	O10
Engelmann spruce–subalpine fir/rock willow open forest	O14
Engelmann spruce–subalpine fir/Labrador tea/crowberry forest	C30
Engelmann spruce–subalpine fir/grouseberry closed forest	C15
Engelmann spruce–whitebark pine/false azalea closed forest	C12
Lodgepole pine/false azalea grouseberry	C20
Lodgepole pine/spruce/crowberry closed forest	C35
Lodgepole pine/Labrador tea closed forest	C29
Black spruce/Labrador tea open bog forest	O11
Black spruce–lodgepole pine/willow/sedge closed forest	C8
White dryas–sedge meadow	H15
Mountain marigold–globeflower wet meadow	H9
Fleabane–valerian herb meadow	H16
Heather–mountain avens–snow willow heath meadow	L4
Heather–everlasting heath meadow	L5
Subalpine fir avalanche complex	S2
Dwarf birch–willow–shrubby cinquefoil shrub meadow	S10

on 4 March 1979.

Productivity

Between 1975 and 1980, 59 classified counts of Woodland caribou yielded a productivity ratio of 36.1 calves/100 females in Jasper. Productivity of the Banff population could not be assessed. Stelfox and Warden Service (1974) found a similar level of productivity in Jasper caribou (38.1 calves/100 females) between 1971 and 1973.

Bloomfield (1979) determined that calves comprised from 7 to 16% of healthy, forest-dwelling caribou populations in B.C. Productivity of Woodland caribou is low because of late sexual maturities – females breed at 28 to 40 months of age and males at 4 years – as well as absence of twinning and high calf mortality (Bloomfield 1979, Bergerud 1978).

The high productivity of Jasper Woodland caribou may represent response to a high level of environmental stress or mortality (Geist 1971) or recovery of the population from a period of underpopulation.

Mortality

Mortality rates cannot be assessed with the data available. The major cause of recorded mortality is predation, with wolves the major predator (Table 3.18). The Woodland caribou of the Rock Creek, Blue Creek and Smoky River watersheds regularly cross the park boundary into the Willmore where they are subjected to hunting pressure in autumn (Bloomfield 1980c). This hunting season was terminated after the 1980 season because of concern over declining caribou stocks in the northern Alberta Rockies (M. Bloomfield, pers. comm.).

MANAGEMENT CONSIDERATIONS

The decline of Alberta Woodland caribou populations by 50% in the last 15 years and the impending threats to their habitat on provincial lands by logging and mineral

Table 3.17. Preferred year-round caribou forage species in Jasper* (derived from Stelfox et al. 1978).

Bromus marginatus	*Carex albonigra*
Pedicularis arctica	*Peltigera apthosa*
Cladina arbuscula	*Equisetum scirpoides*
Valeriana sitchensis	*Lomatium* spp.
Linnaea borealis	*Carex concinna*
Potentilla nivea	*Senecio resedifolius*
Phyllodoce glandulifora	*Rhacomitrium lanuginosium*
Dryas octopetala	*Caltha leptosepala*
Polytrichum piliferum	*Arctostaphylos uva-ursi*
Trollius albiflorus	*Abies lasiocarpa*

development activities (Bloomfield 1980b,c) increases the importance of maintaining healthy, viable populations in Banff and Jasper.

The perceived decline of Banff and Jasper Woodland caribou in this century has been attributed to the combined effects of a gradually warming climate and increased stress from frequent contacts with humans and elk on Woodland caribou summer ranges (Stelfox and Bindernagel 1978). Winter recreational use of caribou ranges creates barriers to movement by compaction of snow along snowmobile and ski trails, as well as allowing predators, particularly wolves, to travel on packed trails deeper into Woodland caribou habitat than might otherwise be possible.

Because Woodland caribou use traditional, learned travel routes, calving grounds, rutting grounds and summer and winter ranges it is essential that disturbance by humans not be allowed to significantly alter these established patterns. At least one travel route crosses the Miette River valley near Clairvaux Creek and is blocked by a highway and a railroad (A. Burstrom, Jasper warden service, pers. comm.).

Critical areas described by Stelfox (1978) should be avoided in the development of any new trails and re-routing of old ones. Trails that venture close to calving areas and rutting areas (described above) should be temporarily closed during the calving period and the rut, and extensive use of Woodland caribou summer ranges should be discouraged since it is at this season that caribou are most susceptible to stress (Stelfox and Bindernagel, 1978). Snowmobiles and cross-country skiing should be controlled or eliminated in Woodland caribou winter ranges.

Although a let-it-burn fire policy may be desirable for some park purposes and may benefit species such as elk and Bighorn sheep, mature and over-mature lichen-producing forests used by caribou should be protected where practical.

In the case of herds which travel outside park boundaries, information regarding their movements, winter range requirements and loss to hunters would facilitate development cooperative management plans with provincial governments. Designation of the Woodland caribou as a threatened species in Alberta would remove this major source of mortality of park caribou (Bloomfield and Sword 1981).

Woodland caribou which remain in the park are not faced with many of the problems that those outside the park boundaries are, such as logging, mining, oil and coal exploration and hunting. Thus it is important that healthy Woodland caribou herds be retained in the parks as areas outside the parks become increasingly incapable of supporting viable populations. If suitable habitat survives outside the parks, Jasper may ultimately provide the stock from which these areas may be repopulated.

Table 3.18. Causes of caribou mortality in Jasper National Park (based on park wildlife cards 1945 to 1980).

Cause of mortality		Caribou killed (by age/sex class)					
		M	F	YOY	YLY	UNK	Total:
Predators:	Cougar		1				1
	Wolf	1	1			2	4
	Lynx				1		1
	Unkown					4	4
Injury			1				1
Peri-natal			1	1			2
Total		1	4	1	1	6	13

MULE DEER *Odocoileus hemionus* **MULE**

STATUS AND DISTRIBUTION

The Mule deer is confined to the western part of North America, ranging from the southern Yukon to Mexico and east as far as southeastern Manitoba and the Dakotas (Rue 1979). It occurs throughout Alberta, except possibly in the extreme northeast corner of the province. Only one subspecies, O. h. hemionus, is known to occur in this province.

Mule deer were the abundant deer species of the southern half of Alberta during the 1800's but excessive hunting and other factors contributed to a rapid decline in their numbers by the end of the century. Between 1890 and 1912 mule deer were considerede by several observers in the Jasper area (Soper 1970). In the Banff area they were depleted by hunting, competition with domestic livestock and other consequences of the rapid settlement of the Bow valley that followed the establishment of the CPR in 1885 (Millar 1915).

Establishment of Banff and Jasper National Parks allowed mule deer a chance to re-build their depleted numbers such that by 1918 they were again considered common in Jasper (Spreadborough 1919) and Hewitt (1921) could say that in Banff "... mule deer are increasing in numbers and may be seen almost any day... ".

During the late 1930's mule deer again began to decline in Banff, possibly because of competition with the burgeoning elk population (Banfield 1958), but by the 1940's the population was again increasing. No similar decline was observed in Jasper (Clarke 1942, Cowan 1944). However, Cowan (1944, 1945) noted poor yearling survival and conjectured that Jasper's mule deer, though numerous, were in poor vigour and being displaced onto marginal winter ranges because of overpopulation and competition with other ungulates. Although controlled elk slaughters were carried out in both parks to reduce overpopulation, no mule deer slaughters took place.

Mule deer remained common and widespread throughout Banff and Jasper in the 1950's and 1960's (Flook 1956, Banfield 1958, warden cards). At present they occur in summer in all parts of Banff and Jasper, being commonest in the Front Ranges. Winter

Figure 3.42. Distribution of mule deer observations in Banff, summer and winter.

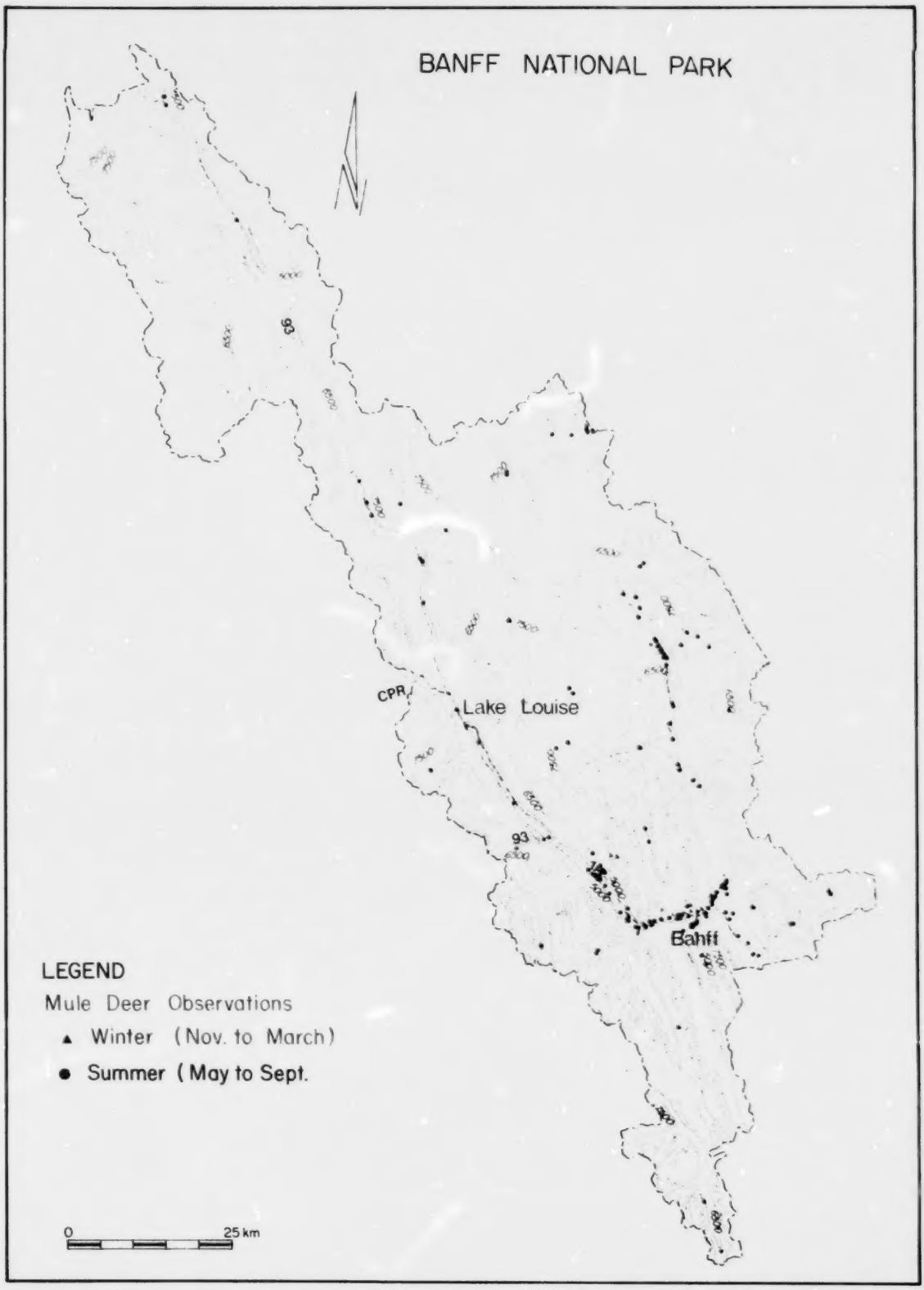
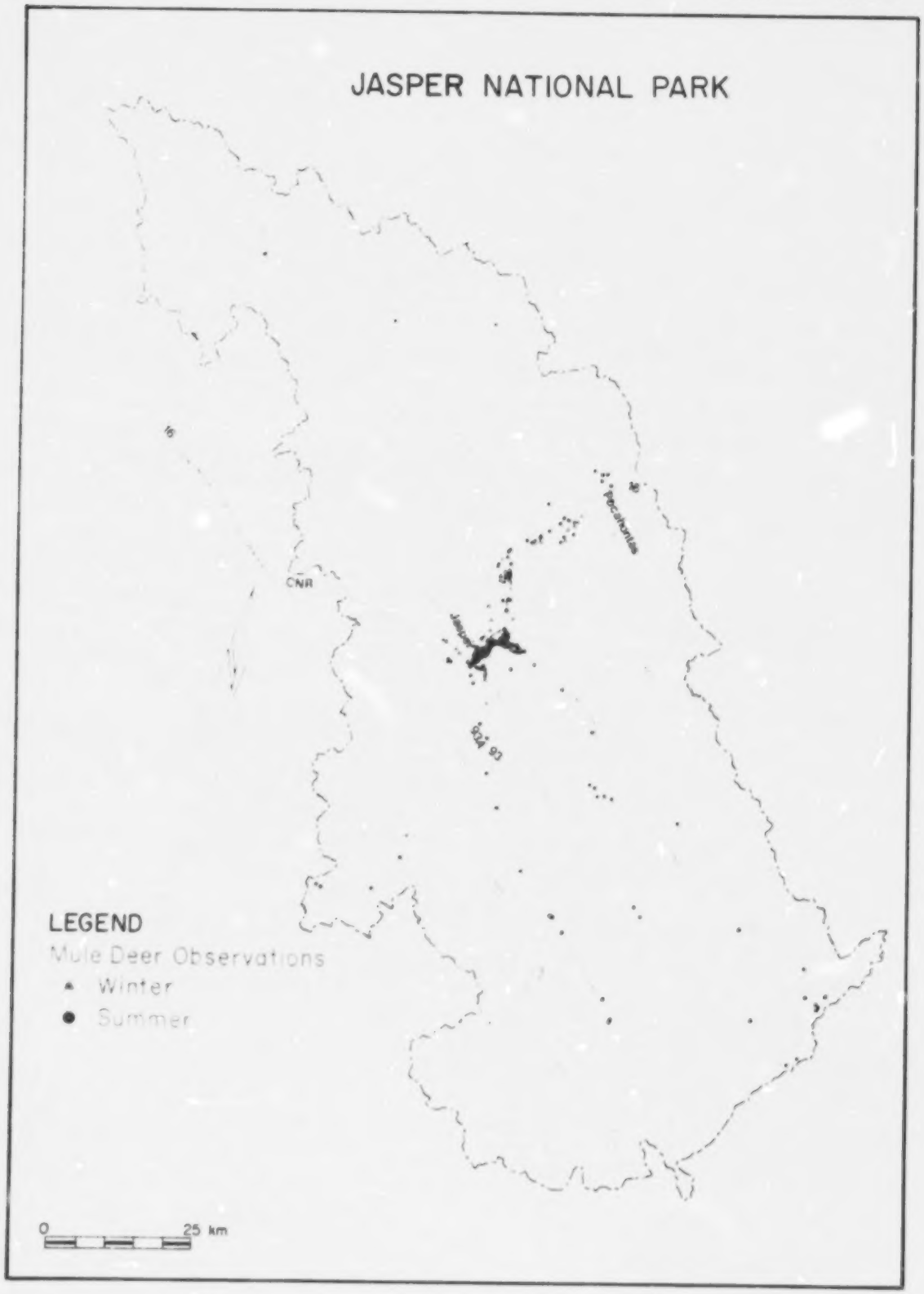


Figure 3.43. Distribution of mule deer observations in Jasper, summer and winter.



distribution is confined to valleys of low snow accumulation such as the lower and middle Athabasca River, lower Snake Indian River, lower Maligne River, lower Brazeau River, lower North Saskatchewan River, lower Red Deer River, Clearwater River, lower Cascade River and lower and middle Bow River valleys (Figures 3.42, 3.43).

Based on the number of observations recorded by wildlife inventory personnel and park wardens since 1976, the most important areas for mule deer in winter are:

lower Athabasca River (101)
Jasper townsite (99)
middle Athabasca River (84)
lower Bow River (35)
middle Bow River (18)
Miette River (11)

HABITAT

Mule deer are primarily animals of the low-elevation valley bottoms. During summer they range at all elevations and are even seen occasionally in the alpine ecoregion, but in winter they are confined almost exclusively to the montane ecoregion and - where winter snow accumulation is low - the lower subalpine ecoregion (Figure 3.44).

Of 366 Mule deer observations during the months May to October since 1975, 211 (58%) were in the montane, 120 (33%) were in the lower subalpine, and only 33 and 2 respectively were in the upper subalpine and alpine. During the months November to April there were 112 records, 107 (96%) were in the montane and the remaining 5 were in the lower subalpine ecoregion.

Pellet group counts and winter tracking also illustrate the preference of deer for low elevation habitats. There were 83.18 deer pellet groups/hectare in the montane ecoregion and 44.37 in the lower subalpine, compared to only 18.85 and 1.37 respectively in the upper subalpine and alpine ecoregions (Table 3.21). Only four tracks were observed in 886.7 km-days of transects in the upper subalpine ecoregion and none in 26.3 kilometer-days of transects in the alpine. There were almost 23 times more deer tracks in winter in the montane ecoregion than in the lower subalpine.

Mule deer frequent slopes and embankments with open coniferous forest or dry grass and low shrub meadows interspersed with patches of forest, alluvial fans or glaciofluvial terraces with aspen forest, dry coniferous forest, or mosaics of early-successional vegetation. Rolling or ridged terrain where dry coniferous forests or grassy slopes alternate with aspen woodland and small wetlands also receive high use by mule deer (Tables 3.20, 3.21).

In winter mule deer are generally confined to south exposures in the montane ecoregion where sun and wind maintain shallow snow. Deer tracks are rarely found in snow deeper than 50 cm and, with the exception of sheep, white-tailed and Mule deer are impeded more severely by deep snow than any other ungulate in Banff and Jasper. Open or closed forests of lodgepole pine, Douglas-fir or white spruce are heavily used, especially forests having dry understories with grasses, rose and bearberry. Mixed coniferous and deciduous forest is also important, but pure aspen stands and open grassland receive only moderate use (Tables 3.22, 3.23).

The use of open, south-facing slopes becomes most pronounced in March and April with the arrival of the first green vegetation on the sites that lose their snow earliest. Such sites (NY3, TA2) are critical to mule deer at a season when they are most physically weakened and need green vegetation to restore their vigour (D. Jacques, U. of C., pers. comm.).

Our data are essentially in agreement with the conclusions of Loveless (1967) in Colorado that snow cover "... of 1 foot hampered deer, and depths of 2 feet or more

Figure 3.44. Habitat use by deer, based on pellet group densities.

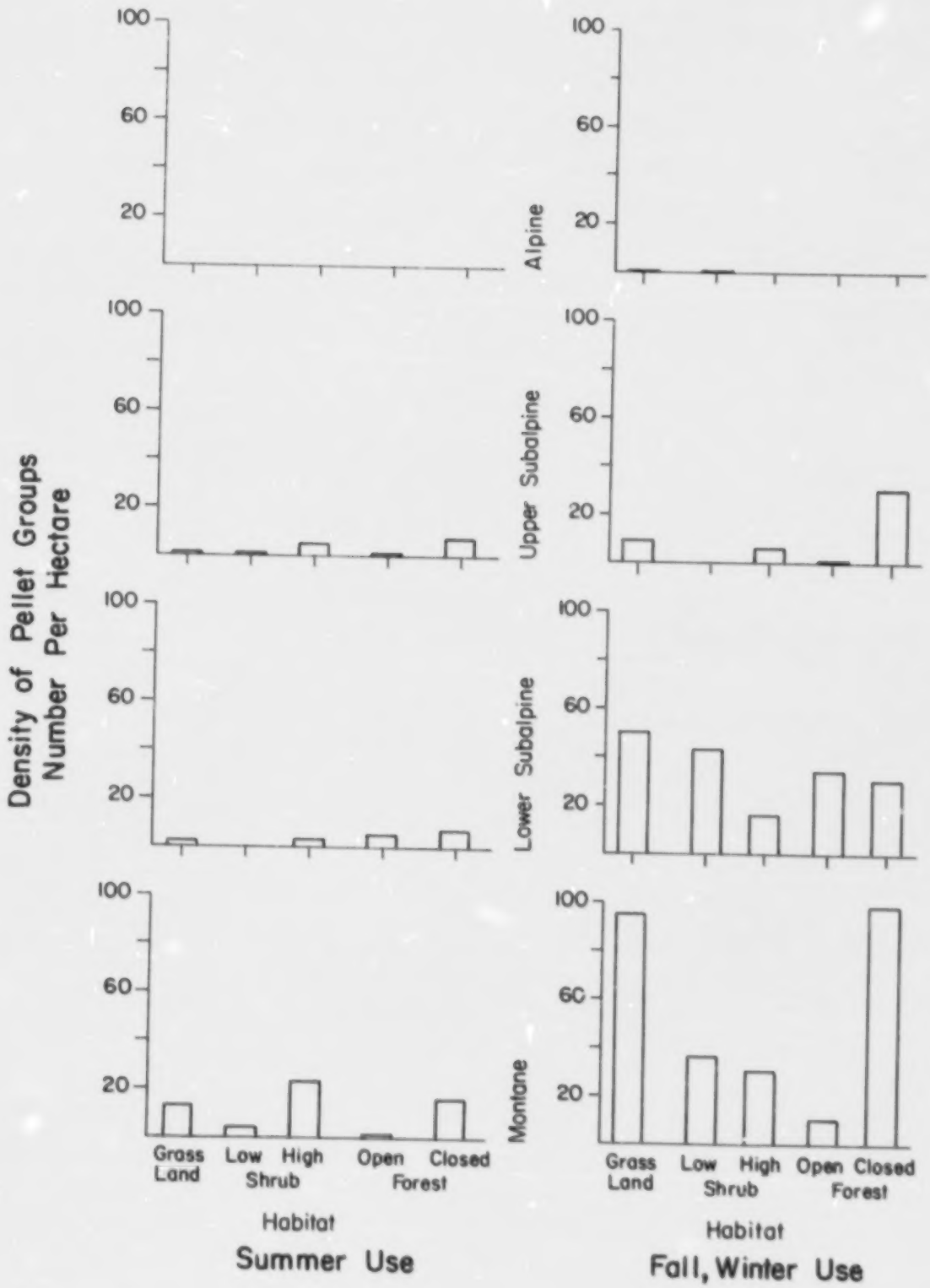


Table 3.19. Deer distribution by ecoregion and season.
Mule and white-tailed deer pellets and tracks cannot be consistently differentiated, most of these records are of mule deer.

Zone:	Average pellet group density/ha			Winter track density /10kmday
	Spring and early summer	*Late summer, autumn and winter*	*All year*	
Montane	10.69	72.49	83.18	0.90
Lower subalpine	6.95	37.42	44.37	0.04
Upper subalpine	3.74	15.11	18.85	0.00
Alpine	0.27	0.91	1.37	0.00

essentially precluded their use of an area... " and that "... Decided preference was shown by deer for ... south- and east-facing slopes and east-facing slopes, and areas which provided both food and cover such as open-timbered, browse understory types. Locations providing cover, but few ... browse species, were little used by deer".

In summer the superficial aspects of mule deer habitat remain essentially the same as in winter, but because of the disappearance of snow mule deer are able to disperse into higher elevations and more remote valleys. Avalanche slopes, burns, alluvial areas and timberline areas are all frequented by mule deer in summer, but the montane and lower subalpine ecoregions continue to support higher densities than the higher elevations (Table 3.21). Bucks are more likely to range at high elevations than does; although an overall ratio of 51 bucks to 100 does has been recorded by wardens in Banff and Jasper, there is a 50:50 ratio of buck sightings to doe sightings in the upper subalpine and alpine ecoregions.

Critical mule deer habitats are those used by mule deer in late winter and early spring when they are at their poorest physical condition (Wallmo et al. 1981). South and east-facing slopes in the montane and lower subalpine, supporting open forest, low shrub or grassland vegetation (NY1, NY3, TA2, TA3, PT3, GA1, GT2, GT1, AT1), are highly important at this season. Specific areas include the north and west side of the lower Athabasca River and Miette River valleys from near Decoigne to the Bedson Ridge area, the lower slopes of the Boule Range along the lower Snake Indian River, the north side of the lower North Saskatchewan River, the north sides of the valleys of the lower Brazeau River, Clearwater River, lower Red Deer River, Panther River and lower Cascade River, and the Sawback and Fairholme Ranges and Tunnel Mountain in the Bow River valley.

LIFE HISTORY

Food habits

Mule deer are basically opportunistic feeders, foraging on the plants which are most palatable or abundant at any one season. "The list of foods that they eat seems to be limited only by the persistence of the investigators" (Wallmo 1978). Kufeld et al.

Table 3.20. Highly important spring and early summer ecosites for deer, based on pellet group data

Ecosite	Pellet groups/ha	Ecoregion	Parent material	Vegetation
PT4	45.0	montane	glacial till	aspen forest
NY3	40.0	montane	ice-contact drift	Douglas fir forest
AZ1	40.0	upper subalpine	ice-contact drift	open spruce-fir forest and willow scrub
MQ1	32.0	upper subalpine	alluvium	spruce-fir forest
NY1	30.0	montane	glacial till	Douglas-fir forest
TA3	28.6	montane	silt (eolian)	white spruce forest
VL4	26.7	montane	alluvium	white spruce forest
GA1	26.7	montane	landslide	lodgepole pine forest
HD4	22.9	montane	alluvium	grassland, scattered pines
AT1	17.5	montane	glaciofluvial	lodgepole pine forest
BK4	15.8	lower subalpine	ice-contact drift	lodgepole pine forest and spruce bogs
NT2	13.7	upper subalpine	alluvium	willow scrub
PL3	13.3	upper subalpine	glacial till	larch-fir forest

(1973) listed 788 kinds of plants that mule deer have been reported to eat in the Rocky Mountain region.

The most favoured foods are succulent forbs however these are only available during spring and early summer. Browse species such as willows, rose and red-osier dogwood are most favoured when in leaf but are used in winter when green forage and grasses are unavailable. Although mule deer will feed on coniferous browse in winter and have been observed in Banff and Jasper feeding on lodgepole pine, Douglas-fir and juniper, deer can only tolerate a diet in which these species comprise less than 20% of their intake. Essential oils of conifers cause damage to the rumen (Wallmo and Regelin 1981).

Forage availability is severely curtailed by deep snow in winter, at which season only coniferous browse and leafless deciduous stems may be available. In New York state forage for whitetails was reduced 97% by only 30 centimeters of snow (Moen and Evans 1971).

Artificial feeding of mule deer in severe winters is generally felt to be unproductive. Although deer can adapt to synthetic feed (but not to hay), most feeding programs begin when starvation is already apparent in the population and many animals have deteriorated too far to adjust to the new feeding regime. The rumen may no longer be suited to digestion of high-quality forage in starving deer (Carpenter and Wallmo 1981). Artificial feeding may be justified in situations where a high sustained yield of mule deer is desired and winter range has been heavily depleted, however these circumstances do not currently exist in Banff and Jasper.

Rut

Table 3.21. Highly important late summer, autumn and winter ecosites for deer, based on pellet group data.

Ecosite	Pellet groups/ha	Ecoregion	Parent material	Vegetation
NY1	290.0	montane	glacial till	Douglas-fir forest
NY3	288.7	montane	ice-contact drift	Douglas-fir forest
HD4	228.6	montane	alluvium	grassland, scattered pines
ML3	200.0	lower subalpine	glacial till	spruce-whitebark pine forest
GA1	186.7	montane	landslide	lodgepole pine forest
TA2	152.7	montane	silt (eolian)	dry grassland
PT3	142.0	montane	glacial till	lodgepole pine forest
HD2	112.4	montane	alluvium	open spruce forest
PT4	110.0	montane	glacial till	aspen forest
GT2	109.6	lower subalpine	glacial till	dry pine forest and grassland
GT1	106.7	lower subalpine	glacial till	open coniferous forest
AT1	103.8	montane	glaciofluvial	lodgepole pine forest
AT3	100.0	montane	glaciofluvial	grassland, scattered pines
BZ2	100.0	lower subalpine	weathered rock	lodgepole pine forest

The rut is during November and early December in Banff and Jasper. Records of rutting behaviour extend from 1 November until 16 December, and are concentrated between 9 and 22 November. There is one record on file of a whitetail buck breeding a mule doe on 9 November 1960 at Jasper townsite, and another of a whitetail buck pursuing a mule doe on 28 November 1970 near Pyramid Lake.

Most bucks have shed their antlers by late January but there is a record of one which still had both antlers on 10 March in Jasper (warden cards).

Birth

The gestation period in mule deer lasts from 183 to 212 days with a mean of about 203 days (Anderson 1981). Assuming most does are bred in mid November, this puts the peak season of fawn drop in the first two weeks of June. The earliest record on file is a newborn fawn observed on 27 May 1962 at Pocahontas. A doe killed by a motor vehicle on 31 May 1959 was carrying two unborn foeti. There is a record of a doe giving birth to a stillborn fawn on 14 June in Jasper townsite.

The latest record of newborn fawns is twins born on 22 July in Banff townsite. The doe in this case must have been bred in late December or early January.

Lick Use

Mule deer, like other ungulates, use both natural and artificial mineral licks. There are numerous records in both Banff and Jasper of mule deer licking at salt blocks near back country patrol cabins and licking the surfaces of salted highways in winter.

Table 3.22. Highly important late summer, autumn and winter vegetation types for deer, based on pellet group data.

Description	*Vegetation type*
Lodgepole pine/juniper/junegrass savannah	H6/C3
Douglas-fir/juniper-bluebunch wheatgrass open forest	O5
Douglas-fir/hairy wildrye forest	C1
Juniper-wheatgrass-blue flax-pasture sage grassland	H19
Balsam poplar/buffaloberry forest	C17
Engelmann spruce-whitebark pine/false azalea forest	C12
Junegrass-everlasting-wild blue flax grassland	H6
Wheatgrass-pasture sage grassland	H7
White spruce-Douglas-fir/feathermoss forest	C5
White spruce/twining honeysuckle forest	C2
Needlegrass-oatgrass-fescue grassland	H13
White spruce/shrubby cinquefoil/berry open forest	O3
lodgepole pine/buffaloberry/showy aster forest	C6
White spruce/prickly rose-twinflower forest	C27
Engelmann spruce-subalpine fir/rock willow open forest	O14
Lodgepole pine/juniper/berry open forest	C3
Aspen/prickly rose/berry open forest	O1
White spruce/buffaloberry forest	C26
Lodgepole pine-spruce/buffaloberry/grouseberry forest	C18
Creeping juniper-wheatgrass dune grassland	L6
Lodgepole pine/false azalea/grouseberry forest	C20
Lodgepole pine-white spruce/green alder/feathermoss forest	C10
Spruce/arrow grass-sedge open bog forest	O7
Aspen/hairy wildrye-junegrass avalanche grassland	H14
White spruce/juniper-berry open forest	O17

Use of natural mineral licks has been recorded as early as 21 June and as late as 10 September. Based on six records it appears that females use licks during the summer and males in September. All records are from wet, seepage-type licks.

Productivity

Because of the tendency of does to hide their fawns for long periods, especially during the first few weeks of the fawns' lives, the fawn: doe ratio is not considered a reliable indication of deer productivity. The average number of fawns accompanying a doe gives an indication of productivity since twinning is most frequent in vigorous, productive populations (Wallmo 1978).

Between 1945 and 1976 park wardens recorded 106 single does accompanied by young in Banff and 224 single does accompanied by young in Jasper. The average number of fawns per doe was 1.47 in Banff and 1.48 in Jasper, with three observations of triplets in Banff and five in Jasper.

Mortality

Road-kills are by far the most important source of mule deer mortality, accounting for 67% and 63% respectively of deer reported killed in Banff and Jasper between 1945 and 1980 (Table 3.24). If the destruction by wardens of deer injured by road traffic are included in the "road-kill" totals, the mortality percentages increase slightly.

Table 3.23. Highly important spring and early summer vegetation types for deer, based on pellet group data.

Description	*Vegetation type*
Douglas-fir/juniper-bluebunch wheatgrass open forest	O5
Lodgepole pine/juniper/junegrass savannah	H6/C3
Needlegrass-oatgrass-fescue grassland	H13
Mixed aspen/pine forest	C16/C6
Mixed aspen/spruce forest	C16/C4
Engelmann spruce-subalpine fir/valerian-fleabane open forest	O9
Willow/horsetail shrub thicket	S7
White spruce/red-osier dogwood/horsetail forest	C17
Douglas-fir/hairy wildrye forest	C4
Engelmann spruce-subalpine fir/rock willow open forest	C1
Lodgepole pine-spruce/buffaloberry/twinflower forest	O14
Willow/timber oatgrass shrub meadow	S11
Lodgepole pine/buffaloberry/showy aster forest	C6
Wheatgrass-pasture sage grassland	H7
Engelmann spruce-subalpine fir/grouseberry forest	C15
Lodgepole pine/pinegrass-dwarf belberry forest	C9
Creeping juniper-wheatgrass dune grassland	L6
Lodgepole pine-spruce/feathermoss forest	C11
White spruce-Douglas-fir/feathermoss forest	C5
Lodgepole pine/false azalea/grouseberry forest	C20
Junegrass-everlasting-wild blue flax grassland	H6
Aspen/hairy wildrye-showy aster forest	C22
Lodgepole pine/juniper/berry forest	C3
Dwarf birch-willow/wormwood shrub meadow	S4

The distances traversed by railway tracks in Banff and Jasper are similar, yet the number of mule deer deaths due to collisions with trains is 13 times higher in Jasper than in Banff. These differences in mortality are attributed to the fact that the CNR in Jasper traverses a greater amount of highly important Mule deer habitat - steep south-facing slopes with grassland, Douglas-fir forest and open white spruce forest (NY3,TA2) - than the CPR in Banff. Combined, mortality resulting from road and rail traffic collisions accounted for 73 percent of all known cases of mule deer mortality in Banff and Jasper.

Seven predators of mule deer have been identified in Banff and Jasper (Table 3.25). In Banff, the coyote is the major predator, whereas in Jasper the wolf is. Bowen's (1978) study of coyotes in Jasper showed that the mean percent frequency of mule deer in coyote kills was 28 percent. The cougar features as the third most important mule deer predator, being responsible for 15 percent of all cases of predation in the two parks. Among the age-classes of deer, the most heavily exploited by predators are yearlings and adult females.

The miscellaneous causes of mortality documented for inclusion in Table 3.24 include poaching, starvation, drowning, intraspecfic aggression, and over-dosing with a tranquilizer drug.

MANAGEMENT CONSIDERATIONS

Maintenance of undisturbed late winter/early spring habitat along the lower, south-and east-facing slopes of major river valleys in Banff and Jasper, is critical to the

Table 3.24. Causes of mule deer mortality in Banff and Jasper National Parks (based on park wildlife cards, 1945 to 1980).

Cause	Banff	Jasper	Total
Road kill	185	336	521
Predator	39	52	91
Railroad kill	6	72	78
Injury[0]	16	26	42
Miscellaneous[00]	6	12	18
Unknown	30	26	56
Totals:	282	524	806

[0] Includes injured animals destroyed by wardens.
[00] See text.

on-going well-being of mule deer in these parks. Mule deer exist under marginal conditions in the Rocky Mountains and it is these small pockets of habitat, where shallow snow and abundant forage prevail, that enable them to exist. Even so, periodic population declines should be expected to coincide with severe winters.

The extent to which mule deer populations in the Bow and Athabasca valley have suffered as a consequence of railroad and highway accidents cannot be determined in the absence of a more detailed census of mule deer numbers. Mule deer are less abundant today in the lower Bow River and lower Athabasca River valleys than indicated by Cowan (1945), Flook (1956) and Banfield (1958). An average of 52 Mule deer were killed annually on the trans-Canada highway alone between 1976 and 1978 (Flygare 1979). In order to sustain a mortality rate of this magnitude, and no other mortality, the deer population would have to exceed 175 individuals.

It is unlikely that present mule deer populations in Banff and Jasper can continue to sustain the existing level of highway and railroad mortality without declining. Increased traffic volumes and more severe winters than were experienced in the last 10 years are both likely to further jeopardize mule deer populations. Elimination of unnatural mortality by fencing or other means is essential to the maintenance of mule deer populations in the lower Athabasca River, Bow River and Miette River valleys.

Further study of mule deer in Banff and Jasper is warranted by the lack of adequate data on population size and dynamics, seasonal ranges, and the extent to which park mule deer may wander outside the parks.

Mule deer readily adjust to moderate levels of human activity. Jasper townsite and the Banff Centre on Tunnel Mountain are used extensively by wintering mule deer. Planning of park facilities, by taking into account the provision of adequate food plants and cover, could minimize range loss to mule deer.

Table 3.25. Sources of mule deer predation in Banff and Jasper National Parks (based on park wildlife cards, 1945 to 1976.)

		Mule deer killed (by age/sex class)					
Predator	**Park**	**M**	**F**	**YOY**	**YLY**	**UNK**	**Total:**
Wolf	B	1	1	2	5	3	12
	J	0	2	0	2	6	10
Coyote	B	1	1	2	5	2	11
	J	0	2	3	0	5	10
Dog	B	1	0	0	1	0	2
	J	2	0	0	3	0	5
Cougar	B	1	2	0	0	1	4
	J	2	2	1	0	2	7
Wolverine	B	0	0	0	0	0	0
	J	0	2	0	0	0	2
Lynx	B	0	0	0	0	0	0
	J	0	0	0	1	0	1
Grizzly	B	0	0	0	0	1	1
	J	0	2	1	0	0	3
Unknown	B	0	1	0	1	2	4
	J	2	0	1	0	1	4
Totals		10	15	10	18	23	76

B=Banff
J=Jasper

WHITE-TAILED DEER *Odocoileus virginianus* **WHIT**

STATUS AND DISTRIBUTION

The White-tailed deer occurs throughout most of the forested part of North America except for northern British Columbia, California and the Great Basin states, and Baja California (Banfield 1974). Two subspecies occur in Alberta. *O. v. dacotensis* occupies the prairie, aspen parkland and mixed forest regions east of the Rocky Mountains, while *O. v. ochrourus* - a subspecies which occurs primarily in southeastern British Columbia - has been reported in the Rocky Mountains in Waterton, Banff and Jasper. The extent to which these two subspecies intergrade in Banff and Jasper has not been studied.

The status of the white-tailed deer in Alberta has varied markedly during recorded history. During the 1800's Alberta was "... populated with mule deer only" (Halls 1978) except in the foothills where White-tailed deer "... were found in fair numbers ... when the early explorers first came. They probably also existed n the Cypress Hills" (Webb 1959). Webb considered the whitetail to be the "deer of the future" in Alberta, describing its spread throughout southern and central Alberta in this century. Agriculture, forest clearing and fire control have led to the development of an extensive aspen

Table 3.26. Causes of white-tailed deer mortality in Banff and Jasper National Parks (based on park wildlife cards, 1945 to 1980.)

Cause	Banff	Jasper	Total
Road kill	41	16	57
Injury	1	0	1
Predation	5	0	5
Unknown	4	1	5
Totals:	51	17	68

parkland belt and the growth of dense riparian forests in areas where previously there had been little habitat capable of supporting whitetails. Depletion of the more easily-hunted mule deer may have further facilitated the spread of White-tailed deer in Alberta.

Today whitetails are abundant in most parts of Alberta except the far north and the Rocky Mountains. From what little documentation of the historical status of whitetails in the Rocky Mountains is available they evidently occur today in similar locations and comparable densities to the early part of the century.

McCory and Blood (1978) estimate a population of about 40 White-tailed deer in Yoho National Park and indicate that the population has been around 20 to 40 since at least the 1920's. They feel Yoho's whitetails migrate in winter to the Columbia valley, outside the park. A resident population has long been present in the Kootenay River valley of Kootenay National Park, where 64 were counted along the road in one day in May 1945 (Cowan 1945). East of Banff, the White-tailed deer is considered the "... most common deer and probably the most numerous ungulate" along the Kananaskis River (Salt 1976), but it was not recorded there before the 1950's. Halls (1978) feels that in Canada generally White-tailed deer "... are living in marginal habitat. Thus, severe winters are apt to cause marked declines in population levels... ". This is probably true to an even greater degree in the valleys of the Rocky Mountains where suitable winter habitat is confined to montane valley floors and routes for migration or dispersal from more hospitable areas are few.

As early as 1915 it was felt that whitetails were "increasing" in Banff and Jasper (Millar 1915). Cowan (1945) failed to observe any whitetails in Jasper during 3 years of concentrated work in the lower Athabasca River valley, and mentioned only the lower North Saskatchewan River area as the location of a small band that wintered outside the park either in B.C. or lower on the North Saskatchewan River. Hatter (1945) also observed whitetails only in the North Saskatchewan River drainage although he noted that warden "... LaCasse reports White-tailed deer on the increase in the Castle Mt. District". Warden records indicate that by the 1940's, at least, there was a small population present in summer along the middle Bow River as well as several sightings in summer near Palliser and Healy Passes.

In Jasper there are no records of whitetails earlier than 1943 when one was seen along the Miette River. By the late 1950's White-tailed deer were being recorded in summer along the lower Brazeau River, lower Snake Indian River and middle Athabasca River, and a small resident population was present in the lower Athabasca River and Miette

River valleys (Jasper warden cards). It is not possible to determine whether these populations became established during the middle of this century or whether this secretive, forest-dwelling deer was always present in such low numbers that it escaped detection.

At present there are resident populations of White-tailed deer in the lower Athabasca River, Miette River and lower Bow River valleys and, possibly, along the lower Brazeau River and lower North Saskatchewan River. There are up to 3 records each since 1976 from the Alexandra River, lower Cascade River, Clearwater River, Panther River, lower Red Deer River, middle Snake Indian River and Blue Creek valleys (inventory files) however these are all summer records of no more than 2 animals and represent stragglers from populations that range at lower elevations in winter.

The maximum single count since 1946 is 5 and it appears that even where it occurs regularly, the White-tailed deer is scarce and thinly distributed. White-tailed deer are frequently seen with Mule deer and there are several records of whitetail bucks pursuing or breeding mule does, further attesting to the low population densities of whitetails in Banff and Jasper.

HABITAT

The paucity of records of White-tailed deer in Banff and Jasper makes an accurate assessment of habitat use impossible. In general, whitetails occur in summer in the montane and lower subalpine ecoregions in alluvial habitats and areas supporting poplars and other deciduous vegetation.

Of 221 observations of White-tailed deer reported by park wardens and wildlife inventory staff since 1975 in Banff and Jasper, the majority were in disturbed habitats (67) and coniferous forests (52). Disturbed habitats included seeded roadsides, gravel quarries and roads. Other habitats in which whitetails were recorded include mixed coniferous/deciduous forest (24), shrubby meadows and slopes (25), and grassland (18). There were only 6 records of whitetails at or above timberline and only 13 records in pure aspen stands and deciduous growth.

Only 42 of the observations were between November and April, lending credence to Cowan's (1945) and McCrory and Blood's (1978) beliefs that whitetails migrate from the mountains to winter in the foothills of Alberta or the lower valleys of B.C.. There are only 3 records for January and February.

Of the 42 observations between November and April, 21 were in disturbed habitats, 9 in coniferous forest, 5 in grassland and 3 in mixed forest. This suggests that whitetail habitat preferences are essentially the same in winter as in summer in Banff and Jasper.

LIFE HISTORY

Food Habits

As is the case with mule deer, White-tailed deer are opportunistic feeders in the sense that their diet varies from season to season depending on which forage species are most abundant and most nutritious at the time. In spring and early summer whitetails feed on new grass, green forbs and wetland plants. Deciduous shrubs such as rose, aspen, willow, red-osier dogwood and others are used at all times of the year but particularly in winter (Rue 1979). Disturbed sites, burns and alluvial areas are especially important to whitetails because of their high production of young browse plants.

Rut

Although warden records from 1944 to 1976 in Banff do not include observations of rut-associated behaviour, there were two records of rutting in Jasper. On 9

November 1960 a whitetail buck was seen breeding a mule doe, and on 28 November 1970 a whitetail buck was seen pursuing a mule doe. It appears that the two species breed at the same time, during November and early December. There are five records of probable hybrids, all from Jasper, and 21 records of whitetails associating with mule deer during the period 1944 to 1976.

Birth

There are very few records of young fawns in Banff and Jasper; the earliest record is 28 May 1973 at Whistler's Campground. The gestation period averages 200 to 210 days (Rue 1979) and most fawns are probably born in June.

Lick Use

There are no records of whitetails using natural mineral licks in Banff and Jasper although many tracks seen at a wet lick in the Clearwater valley on 11 August 1979 were believed to be White-tailed deer tracks. There are several records of whitetails using salt blocks in horse pastures (park wildlife cards).

Productivity

Only 30 records of single doe whitetails with young of the year have been recorded in Banff and Jasper since 1944. Twelve of these does had twins and the rest were accompanied by single fawns. The average of 1.4 fawns per doe under-represents the actual productivity of whitetails in Banff and Jasper since it is based on records from May until December during which time there is some fawn mortality, and since does tend to hide very young fawns.

Mortality

Of 68 records of white-tailed deer mortality since 1944 in Banff and Jasper (Warden records, wildlife inventory records) 57 (84%) were highway mortalities. Predation accounted for 5 mortalities (Table 3.26) and it appears that by far the most significant source of White-tailed deer mortality is the automobile.

MANAGEMENT CONSIDERATIONS

White-tailed deer are probably the least abundant ungulate in Banff and Jasper and appear to occur at comparable densities and in the same areas as they did in the first half of this century. The montane ecoregion is probably critical to this species in the Rocky Mountains. Further research is needed to determine where Banff and Jasper's whitetails winter in order to allow informed management of critical habitats of this species.

Highway mortality, especially in Banff, is by far the major source of White-tailed deer mortality and should be reduced by better highway design, lowered speed limits, fencing or other deterrents. Deer are somewhat more tolerant of high unnatural mortality than less productive species such as elk and sheep.

MOOSE *Alces alces* **MOOS**

STATUS AND DISTRIBUTION

The moose is a circumpolar species occurring in the coniferous forest regions of North America, Asia and Europe. In North America it occupies the northern Rocky Mountains and the boreal forest region. Two subspecies occur in Alberta. *A. a. shirasi* occupies the southern Rocky Mountains and their foothills. The larger, darker subspecies *A. a. andersoni* ranges throughout northern Alberta and the Rocky Mountains as far south at least as Banff National Park (Banfield 1974). The extent to which these two subspecies intergrade is not known.

Moose occur throughout all drainages of Banff and Jasper at low densities (Figures 345, 346). Sightings or tracks were recorded in 38 of 59 watersheds during this inventory, with the most records being in the Mistaya River (21 of 217 records), middle Bow River (19), middle Maligne River (16), lower Athabasca River (14) and upper Bow River (12) watersheds. Moose are regularly seen between the upper Bow River meadows and Waterfowl Lakes but elsewhere they are patchily distributed. Estimates of moose population are difficult to derive and are usually considerably lower than the number actually present (Peterson 1955) due to the solitary and nocturnal nature and the forested habitat of this species.

The winter distribution of moose is no less extensive than the summer distribution, although winter concentrations of moose do occur in some areas. Moose tracks were recorded in 37 of 55 watersheds surveyed by winter tracking. Winter moose pellets were recorded in 54 watersheds and in fact moose probably winter in all drainages of the park, being less restricted by deep snow than are other ungulates (Kelsall and Telfer 1971). This is the only ungulate occuring in Banff and Jasper which was found at higher winter densities in Main Range watersheds (1.34 tr/10kmda) than in Front Range watersheds (1.21 tr/10kmda). On the basis of winter tracking data the most heavily used watersheds are the Cairn River, Siffleur River, Healy Creek, Meadow Creek, Smoky River and Johnston Creek. The Blue Creek meadows, upper Rocky River, Parker's Ridge-Nigel Creek area, Bow meadows/upper Mistaya valley, Miette River, and middle Bow River are areas in which moose are regularly known to concentrate in winter (Warden records). Moose numbers have decreased significantly in the latter two areas due to excessive mortality on highways and railroads that transect these areas.

From the reports of early travellers and explorers in the Rocky Mountains it appears that moose were widely distributed and sufficiently common to be a major meat source during the nineteenth century. David Thompson considered moose plentiful near the lower Red Deer River in 1800 (Hopwood 1971) and along the North Saskatchewan in 1807 (Coues 1897). In 1859 James Hector and his party were saved from starvation by an encounter with Indians who had killed seven moose near Lake Louise. In the same year the Earl of Southesk's guide also killed three moose in the Bow valley (Southesk 1875). Perhaps the most impressive indication of moose numbers was Walter Moberley's hunting trip between the Athabasca and Smoky Rivers in 1855 when his party "killed more than seventy moose on the trip" (Moberley 1929).

By the end of the nineteenth century, however, moose were becoming rare. Over-hunting must certainly have been a factor in their decline, as may have been disease (Spry 1967, Soper 1970) and habitat loss. Lewis Swift, a long-time resident at Henry House, had not seen any moose in his area in the seventeen years prior to 1911 (Hollister 1912) and Hollister himself considered the species rare in the area.

Most reports agree that moose were nearly wiped out in the Rocky Mountains of Alberta by the early part of this century (Soper 1970). During the 1920's "... the sight of a moose in Banff, Yoho, and Kootenay Parks was quite unusual" (Tony Lascalies [H. Green], Banff; in Peterson 1955). The abundance of fire-successional habitats and the protection afforded moose by the national parks enabled them to increase until by the late

Figure 3.45. Distribution of moose observations in Banff, summer and winter.

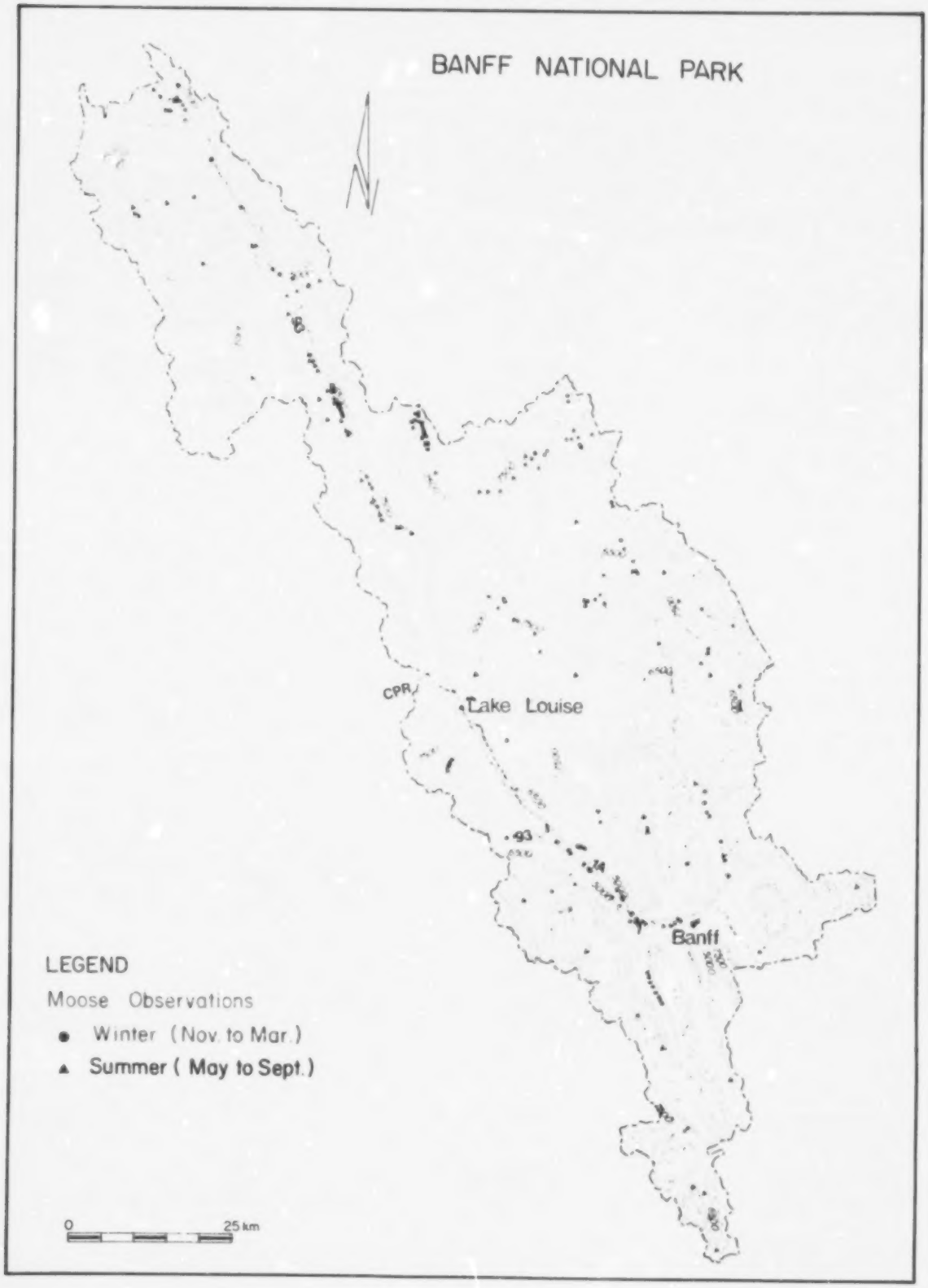


Figure 3.46. Distribution of moose observations in Jasper, summer and winter.

thirties and forties they were "... well represented in suitable localities where lakes and brushy valleys existed..." in Jasper (Soper 1970) and "... extremely abundant, especially in the Bow River valley between Banff and the Continental Divide, and between Lake Louise and the Saskatchewan" (H. Green, op cit.)

Soper's account of moose status and distribution compares well with the present-day status of moose in Jasper, however some of the areas of concentration have changed. The Cairn Pass, Rocky Forks and Mowitch Creek areas no long support notably large moose concentrations as indicated by Cowan (1943) and Flook (1956), although moose still concentrate in winter near Summit Lakes and in the Blue Creek meadows. A major new winter range has developed along the lower Chaba River in an extensive burn.

Moose are rarely seen in the Bow and lower Athabasca valleys compared to early reports. The decline in moose population in these areas may be partly due to habitat change as lodgepole pine forests on the uplands have matured, however it is also apparent that moose are "... particularly vulnerable to both highway and rail traffic in the Bow [and Athabasca] valley. It is doubtful if natural increase is keeping up with mortality" (Holroyd 1979a).

The moose population in the Kananaskis area, east of Banff, is considered small and "... sensitive to disturbance" (Salt 1976). McCrory and Blood (1978) estimate a total population of between 50 and 100 moose in Yoho National Park and feel there has been a gradual population increase during the 1970's. In Waterton Lakes National Park moose numbers are considered relatively stable at around 30 or 40 and have been at that level since the late 1940's (Courtney 1971). It appears that in the Rocky Mountains generally moose had recovered by the late 1940's and 1950's from very low populations and local extirpations in the early 20th century, and have remained relatively stable since that time except in areas where local mortality factors such as highway and railroad kills have caused declines. Moose are ubiquitous in the Rockies but never attain the population densities of the foothills and boreal regions (Peterson 1955).

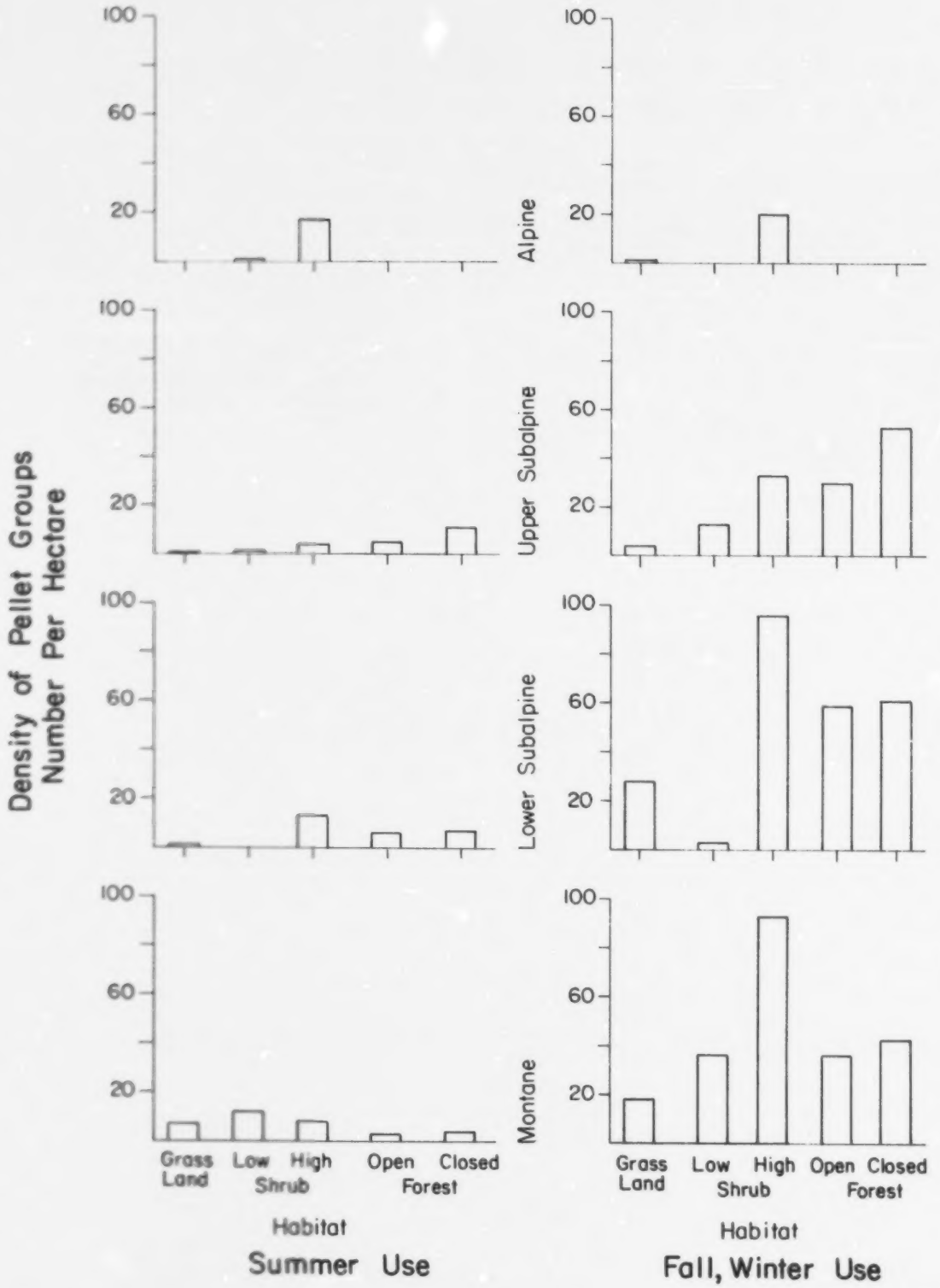
HABITAT

Unlike sheep, goat, caribou and mule deer, all of which tend to prefer stable, "climax" vegetation and use the same traditional ranges from year to year, "... moose populations apparently reach their maximum in the early stages of succession and decrease as the forest reaches maturity" (Peterson 1955, p 153). Consequently, moose habitat is characterized by ecosites where active processes such as alluvial action, avalanching and cold air drainage inhibit the development of climax forest, or by areas where fire has set back plant succession and created the young, shrubby forests favoured by moose.

Alluvial wetlands, particularly in the montane ecoregion, are the most important year-round moose habitat because of their production of willow and poplar browse and submergent food plants. On 11 May 1946 Herbbert saw 30 moose in the Vermilion Lakes /Muleshoe area of Banff (Banff warden card) and even as recently as 14 February 1972 30 moose were reported in the Vermilion Lakes area. During the late 1940's and the 1950's up to 15 moose regularly wintered in the beaverponds and muskegs around Willow Creek (Jasper warden records). The wetlands along the lower Miette River supported a large moose population year-round (Soper 1970, Jasper warden cards). However, the potential importance of wetlands in the lower Athabasca River, Bow River and Miette River valleys has been significantly curtailed during the last decade by increased mortality of moose on railroads and highways. In late winter and spring of 1969 fourteen moose were reported killed along the railway in the Miette valley (Jasper warden cards). In winter 1971/72 nine were killed by trains in the Bow valley.

Montane wetlands produced very high summer pellet group counts (VL3, VL5) and very high winter track counts (VL1, VL3, VL4).

Figure 3.47. Habitat use by moose, based on pellet group densities



Another important habitat type is subalpine shrub meadows which occur in cold air drainage basins, poorly-drained alluvial areas, and colluvial slopes. These areas provide an abundance of willow and herbaceous forage and, though somewhat less potentially important than montane wetlands, are highly important to moose both in summer (MC1, HC4, SX2, KA1) and winter (PP7, HC1, PP6, NT2, HC4).

Alluvial fans and floodplains are of high importance to moose because of frequent flooding which results in immature or open forest stands with willows and poplars growing along watercourses. Of the 22 highly important summer ecosites, 14 are alluvial or boggy and poorly-drained (Table 3.28). Of 15 highly important winter ecosites, 12 are alluvial or poorly drained(Table 3.29).

Moose are more abundant in lower subalpine and upper subalpine habitats than in the montane during most of the year (Table 3.27, Figure 3.117). In winter they are most abundant in the montane, followed by the lower subalpine. This shift to lower elevations in winter may be less a factor of snow depth than it is of more abundant willow and poplar browse in the montane. Moose have relatively lighter foot loadings and higher chests than other ungulates and are thus better able to travel in deep snow (Kelsall and Telfer 1971). In Banff and Jasper highest winter track densities of moose were in the 71 - 80 cm range of snow depths, but tracks were recorded in snow of depths up to 120 cm. In many parts of Banff and Jasper moose are the only ungulates remaining in subalpine valleys by mid winter.

Moose frequent a variety of vegetation types from mature spruce/fir forest to wet sedge and willow meadows. The most heavily-used vegetation types (Tables 3.30 and 3.31) are deciduous or deciduous/coniferous mixed forests, and coniferous forests with shrubby understories containing willow species, red-osier dogwood or bilberry species. Willow and alder thickets along streams, on avalanche slopes, or in poorly-drained areas are also highly favoured.

In forested areas moose occur in comparable abundance in forests of spruce and fir or of lodgepole pine. Understory vegetation and proximity to feeding habitat are of more importance to moose than forest composition.

LIFE HISTORY

Food Habits

Food habits of moose have been most intensively studied in eastern North America, particularly Ontario. That there is some degree of variability in moose diet from one part of its range to another is inevitable, considering the different plant species in one area from those in another, and the varying proportions in which the common species occur.

Balsam fir (*Abies balsamea*), for example, is "... apparently the most abundant and most important winter food of moose... " in eastern Canada (Peterson 1955); yet the closely related subalpine fir of Banff and Jasper is rarely browsed. Similarly, green alder is listed as a "fairly important food" in Ontario (ibid) but is seldom used by any ungulates in Banff and Jasper.

The bulk of the more important food plants described by Peterson (1955) are deciduous shrubs of the genera *Salix, Populus, Betula, Sorbus, Amelanchier, Cornus,* and *Sambucus,* or are aquatic herbs. Similar results for B.C. are described by Cowan et al. (1950). Deciduous shrubs are of limited distribution in Banff and Jasper, occurring at their greatest densities in old burns or on sites subjected to periodic flooding or avalanching. Aquatic vegetation grows most abundantly in the montane wetlands where long growing seasons and warm summers stimulate their growth.

Rut

Table 3.27. Moose distribution by ecoregion and season.

Zone:	Average pellet group density/ha			Winter track density/10kmday
	Spring and early summer	*Late summer, autumn and winter*	*All year*	
Montane	7.68	44.60	52.28	0.20
Lower Subalpine	11.85	61.76	73.61	0.10
Upper Subalpine	8.60	48.36	56.96	0.07
Alpine	6.76	6.21	12.97	0.00

The rutting season of moose in Banff and Jasper lasts from about 10 September until about 10 October. The earliest record of rutting behaviour is 26 August 1961 in the Adolphus meadows (Jasper warden cards). There are three rut records during November, the latest being 30 November 1969 in the upper Athabasca River valley. Late rutting records may be accounted for by the fact that cows which fail to be successfully bred during the normal rut may have up to 2 more estrous cycles until they are successfully bred (Edwards and Ritcey 1958).

Calving

Following an eight month gestation period cow moose bear single or twin calves usually between 20 May and 18 June, with the majority of newborn calves being reported between 25 May and 10 June. (Banff and Jasper warden records). There are three exceptionally early records of new-born calves. A cow and calf were observed on 3 May 1953 seventeen miles west of Banff and the following day the same or another family was reported at McNair Pond. On 11 May 1963 a cow and calf were seen near Snaring warden cabin.

The latest record of a new-born calf is 10 July 1955 on the Mount Norquay road (Banff warden records).

Lick Use

Although moose are known to use licks at most times of the spring and summer, such use has not been well documented in Banff and Jasper. There have been only 4 records of use by moose of licks in Banff since 1947. All were during July, August and September. In Jasper no use of natural licks has been recorded by wardens since 1950, however use of salt blocks in horse grazing areas has been recorded at all times of the year.

Carbyn (1972b) found that moose made heaviest use of a lick on Mud Creek in Jasper in May and June. Peterson (1955) considers spring to be the peak season for lick use by moose, and reports that young of the year rarely use licks. Moose are most commonly associated with wet mud licks and only rarely eat dry soil in the manner of sheep and goats.

Productivity

Although twin calves "... are not uncommon... " (Franzmann 1978), they are seldom recorded in Banff and Jasper. Only 22 of 308 observations of cows with young in

Table 3.28. Highly important spring and early summer ecosites for moose based on pellet group data.

Ecosite	Pellet groups/ha	Ecoregion	Parent material	Vegetation
CA4	75.6	lower subalpine	glacial till	lodgepole pine forest
MQ1	40.0	upper subalpine	alluvium	spruce-fir forest
VL5	31.1	montane	alluvium	willow thicket
VL3	26.7	montane	alluvium	spruce forest and willow scrub
CV1	23.5	lower subalpine	glacial till	lodgepole pine forest and spruce bog
MC1	22.5	lower subalpine	silt (lacustrine)	spruce-pine forest and bog
VD2	18.2	lower subalpine	alluvium	lodgepole pine forest
BY1	18.2	lower subalpine	glacial till	spruce-fir forest
BK1	17.7	lower subalpine	glacial till	lodgepole pine forest and spruce bog
HC4	16.2	lower subalpine	alluvium	willow bog, sedge fen
TZ2	14.6	lower subalpine	ice-contact drift	lodgepole pine forest and spruce-willow bog
VL4	13.3	montane	alluvium	spruce forest
VD1	13.3	lower subalpine	alluvium	spruce-fir forest
SX2	12.5	lower subalpine	glacial till	open spruce-fir forest

Jasper between 1950 and 1976 were of more than one calf. There was a single record of a cow with 3 calves. Twinning is even less common in Banff where only 12 sets were seen out of 331 observations of single cows with young between 1945 and 1976. No triplets have been recorded in Banff.

The ratio of calves to cows varies markedly from year to year in any given population. In one study in Alaska the autumn ratio of calves to cows went from a high of 89.8:100 in 1953 to a low of 13:100 in 1978 (Bishop and Rausch 1974). Productivity is influenced by habitat quality, winter severity, post-natal survival and census accuracy.

Based on warden card data, productivity of moose in Jasper averaged 35.2:100 during the months of August to April. The range was from 14.4:100 in 1951/52 to 56.2:100 in 1968/69.

In Banff the average autumn ratio of calves to cows was 33.6:100 during the years 1944 to 1975, ranging from 9:100 in 1967 to 86:100 in 1955.

In general, the moose populations of Banff and Jasper exhibit fairly stable population levels and lower productivity than other populations which have been studied in Alaska (Franzmann 1978) and northern and eastern Canada (Peterson 1955). Twinning is

Table 3.29. Highly important late summer, autumn and winter ecosites for moose (based on pellet group data).

Ecosite	Pellet groups/ha	Ecoregion	Parent material	Vegetation
WH2	240.0	upper subalpine	colluvium	spruce-fir forest
LV1	170.0	upper subalpine	glacial till	larch-fir forest
ML2	152.7	lower subalpine	glacial till	lodgepole pine forest
CA4	142.2	lower subalpine	glacial till	lodgepole pine forest
BZ2	140.0	lower subalpine	weathered rock	lodgepole pine forest
IB3	128.0	lower subalpine	landslide	spruce-fir forest
FV2	126.7	lower subalpine	colluvium	spruce-fir forest
EG2	126.7	upper subalpine	glacial till	larch-fir forest
PP3	126.1	lower subalpine	alluvium	spruce-fir forest
SB3	123.6	lower subalpine	colluvium	lodgepole pine forest
PR3	117.5	lower subalpine	glacial till	lodgepole pine forest
BZ1	106.7	lower subalpine	weathered rock	spruce-fir forest
HC1	99.4	lower subalpine	alluvium	spruce-fir forest and willow bog
BY2	98.4	lower subalpine	glacial till	spruce-fir forest

less common and fewer cows are accompanied by calves in autumn and winter. Low productivity is a factor of population stability (Geist 1971) and it is possible that this stability is made possible by the presence of habitats that remain in early successional stages due to the presence of avalanching, cold-air drainage and alluvial processes.

Mortality

The major source of documented moose mortality in Banff and Jasper is collision with motor vehicles and trains (Table 3.32). Of 435 instances of mortality recorded by wardens in Banff and Jasper since 1945, 245 (56%) were caused by collisions. More moose were reported killed by motor vehicles (138) than by trains (107).

Predators accounted for 71 (16%) of all documented mortality, with wolves being by far the most important predator (Table 3.33). There were 40 cases of wolf predation on moose. The only other significant predator is the grizzly, which accounted for 13 of the documented cases of predation; however, some of these records may have included bears scavenging carcasses of moose that had died of other causes.

Especially in northern and western Jasper, moose may be a major prey item for wolves since they occur in small groups or singly and are more randomly dispersed in

Table 3.30. Highly important spring and early summer vegetation types for moose.

Description	*Vegetation type*
Engelmann spruce–subalpine fir/tall bilberry forest	C21
Mixed aspen/spruce forest	C16/C4
Open lodgepole pine/menziesia forest (fire successional)	–
Willow alder/mertensia shrub thicket	S6
Open black spruce/Labrador tea bog forest	O11
Beaked sedge meadow	H11
Engelmann spruce–subalpine fir/Labrador tea/crowberry forest	C30
Dwarf birch–willow/wormwood shrub meadow	S4
White spruce/red–osier dogwood/horsetail forest	C4
Dwarf birch–shrubby cinquefoil–willow shrub meadow	S1
Willow/timber oatgrass shrub meadow	S11
Willow/horsetail shrub thicket	S7
Open spruce/arrowgrass–sedge forest	O6
Open lodgepole pine/juniper forest (fire successional)	–
Open Engelmann spruce–subalpine fir/rock willow forest	O12
Engelmann spruce–subalpine fir/grouseberry forest	C15
Dwarf birch–shrubby cinquefoil/needle rush fen	S3
Subalpine larch/chalice flower–everlasting forest	C23
Lodgepole pine–spruce/buffaloberrry/grouseberry forest	C18
Open Engelmann spruce–subalpine fir/willow/hairy wildrye forest	O18
Willow/hairy wildrye shrub meadow	S12
Lodgepole pine/Labrador tea forest	C29

winter than are other ungulates. Since predation is less likely to be observed by wardens than railroad and highway mortality, it may be a more major source of moose mortality in Banff and Jasper than the records indicate. However, railroad and highway mortality are concentrated in the montane ecoregion which is of limited extent and is highly important to moose, particulary in winter. The constant drain on moose populations caused by this unnatural mortality has contributed to declines in moose numbers in the Bow River and lower Athabasca River valley.

Accidents, including falls and entrapment in avalanches, accounted for 21 cases of mortality and drowning for a further 16.

MANAGEMENT CONSIDERATIONS

To the extent that many of the more favoured moose habitats such as alluvial wetlands, avalanche slopes and subalpine shrub meadows are maintained in their early–successional stages by on–going natural processes, the future of moose in Banff and Jasper appears relatively secure. However, extensive tracts of former moose hatitat have been lost due to forest succession, and continued strict fire suppression will lead to further reduction in the potential for Banff and Jasper to support large numbers of moose.

The importance of the Chaba and Vermilion Pass burns to moose illustrates the value of fire to moose.

The heavy mortality of moose on roads and railways, particularly in the highly important montane ecoregion, results in a constant drain on Banff and Jasper's moose populations. Moose numbers have already declined dramatically in the Vermilion Lakes area

Table 3.31. Highly important late summer, autumn and winter vegetation types for moose.

Description	*Vegetation type*
Willow-alder/mertensia shrub thicket	S6
Aspen/hairy wildrye-showy aster forest	C22
Lodgepole pine/pinegrass-dwarf bilberry forest	C9
Engelmann spruce-subalpine fir/rock willow/white heather forest	C24
Engelmann spruce-subalpine fir/tall bilberry forest	C21
Lodgepole pine/Labrador tea forest	C29
Engelmann spruce-subalpine fir/Labrador tea/crowberry forest	C30
Lodgepole pine/false azalea/grouseberry forest	C20
Dwarf birch-willow-shrubby cinquefoil shrub meadow	S10
White spruce/red-osier dogwood/horsetail forest	C4
Lodgepole pine-white spruce/green alder/feathermoss forest	C10
Lodgepole pine-spruce/buffaloberry/grouseberry forest	C18
Dwarf birch-willow/golden sedge-fescue shrub meadow	S9
Willow/horsetail shrub thicket	S7
Engelmann spruce-subalpine fir/grouseberry forest	C15
Dwarf birch shrubby cinquefoil willow shrub meadow	S1
Open Engelmann spruce-subalpine fir/willow/hairy wildrye forest	O18
Dwarf birch-willow/wormwood shrub meadow	S4
Lodgepole pine (Engelmann spruce)/crowberry/lichen forest	C35
Open lodgepole pine/juniper forest (fire successional)	-
Douglas fir/hairy wildrye forest	C1
Yellow dryas willow herb mat	H8
Open Engelmann spruce-subalpine fir/valerian-fleabane forest	O9
Creeping juniper/wheatgrass meadow	L6
Dwarf birch-shrubby cinquefoil/needlerush fen	S3

from more than 30 in the late 1950's and 1960's (Banff warden cards) to fewer than 5 today in spite of eutrophication of the lakes, which has maintained the area as high-quality habitat. If mortality is not effectively reduced along railroads and highways, this drain could lead to the elimination of moose in large parts of both Banff and Jasper.

Controlled burning, or a more laissez-faire fire management policy, would to some extent offset this drain by creating new - albeit temporary -habitat in areas remote from roads and railroads.

Table 3.32. Causes of moose mortality in Banff and Jasper National Parks (from park wildlife cards, 1945 to 1980).

Cause	Banff	Jasper	Total
Road kills	56	82	138
Railroad kills	43	64	107
Predators	22	61	83
Unknown	26	40	66
Miscellaneous accidents	10	9	19
Drowning	5	11	16
Malnutrition/starvation	4	7	11
Avalanches	2	0	2
Disease	2	0	2
Poaching	1	1	2
Intraspecific aggression	0	1	1
Totals:	171	276	447

Table 3.33. Sources of moose predation in Banff and Jasper National Parks (from park wildlife cards, 1945 to 1976).

Predator	Park	Moose killed (by age/sex class) M	F	YOY	YLY	UNK	Total
Wolf	B	2	2	2	1	4	11
	J	10	5	3	6	8	32
Coyote	B	0	0	0	1	1	2
	J	0	0	0	0	0	0
Grizzly	B	2	2	1	0	2	7
	J	4	4	1	1	4	14
Wolverine	B	0	0	0	0	0	0
	J	0	1	0	0	0	1
Unknown	B	0	0	0	1	0	1
	J	0	1	0	0	0	1
Cougar	B	0	0	0	1	0	1
	J	0	0	0	0	0	0
Totals		19	14	7	11	19	70

B=Banff
J=Jasper

ROCKY MOUNTAIN ELK *Cervus elaphus*

STATUS AND DISTRIBUTION

Rocky mountain elk occur in the central to northern Rocky mountains including southeastern British Columbia, the foothills in Alberta and isolated populations in the prairie provinces (Schmidt and Gilbert 1978). Many of the isolated populations as well as major herds occur within park boundaries. Historically, elk ranged from British Columbia to Ontario (McCrory and Blood 1978).

It appears that in the area that is now Banff and Jasper elk occurred primarily in the montane portions of the major river valleys and locally along the Front Ranges before the mid-nineteenth century.

Tanner (1950a) reported that elk remains were found in an excavation in Banff townsite and that elk antlers had been found buried two feet deep in a Banff resident's yard. Christensen (1971) reported elk remains from various archaeological sites in Banff National Park.

David Thompson found elk "plentiful" in the vicinity of the Ya-ha-Tinda on the Red Deer River in 1800 (Hopwood 1971) and near the North Saskatchewan in 1807 (Coues 1897). Alexander Henry reported elk at the confluence of the Howse and North Saskatchewan at about the same time. Both George Simpson (1847) and the Reverend Rundle (1847) reported elk in the Bow valley. There are few historical records, however, of elk in Jasper or the higher mountain valleys of Banff.

In 1848 elk suffered a major epidemic in the North Saskatchewan valley (Spry 1968). James Hector noted tracks near the North Saskatchewan in 1859 but the Earl of Southesk (1875), an avid hunter, traversed the Brazeau, North Saskatchewan and Bow drainages without recording any. While elk may have been locally abundant in the Front Ranges of the southern Rockies during the early 1800's, it appears that they were declining significantly by mid-century. Soper (1970) attributes the decline to "... a series of heavy winters and ... heavy killing by white and Indian hunters". By the 1890's elk had completely disappeared except for a small population in the Brazeau drainage (Stelfox 1964).

In 1916 there were 32 elk in Banff, the descendants of five Manitoba elk that had been brought to the park in 1900 to form a display herd. There were no free-ranging elk other than a few that may have summered in the Kananaskis area, wintering in B.C. (Chief Game Guardian Sibbald, park files). In 1917, 57 elk were shipped from Yellowstone to Banff and held until the following spring when most were released (Green 1946). In January 1920 a further 206 Yellowstone elk were shipped to Banff. Twelve died en route, 53 were released at Massive, and 141 were released at Duthill (Lloyd 1927, Green 1957). During the same year 89 were released at Jasper (Soper 1970).

The re-introduced herds multiplied rapidly and by the early 1940's occupied all the areas they occupy today. A combination of favourable weather conditions, abundant early-successional vegetation where fires had burned half a century earlier and, no doubt, hybrid vigour created ideal conditions for the spread of elk throughout the Rockies.

Based on assessments of elk populations, their impact on vegetation, and their competition with other ungulates, notably sheep, controlled elk slaughters were initiated in the 1940's (see below, Management History). Slaughters continued in Banff between 1941 and 1969 and in Jasper between 1945 and 1970.

Range loss through forest succession, increased mortality on roads and railways, recovery of wolf populations from their decimation in the 1950's, and a severe winter in 1974/75 (N. Woody, A. Burstrom, Jasper warden service, pers. comm.) all contributed not only to eliminate the perceived need to cull herds in Banff and Jasper, but to

Figure 3.48. Distribution of elk observations in Banff, summer and winter.

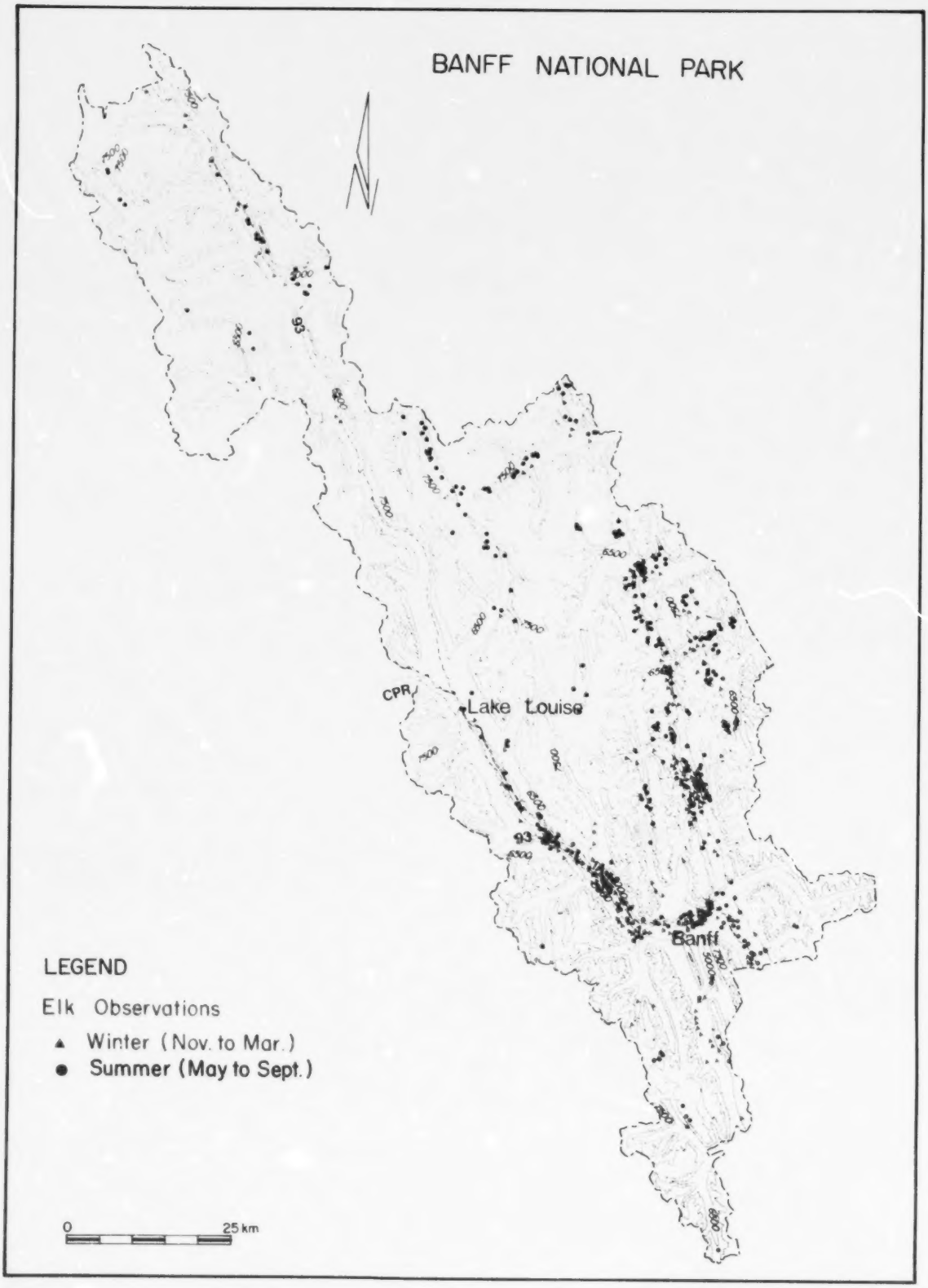
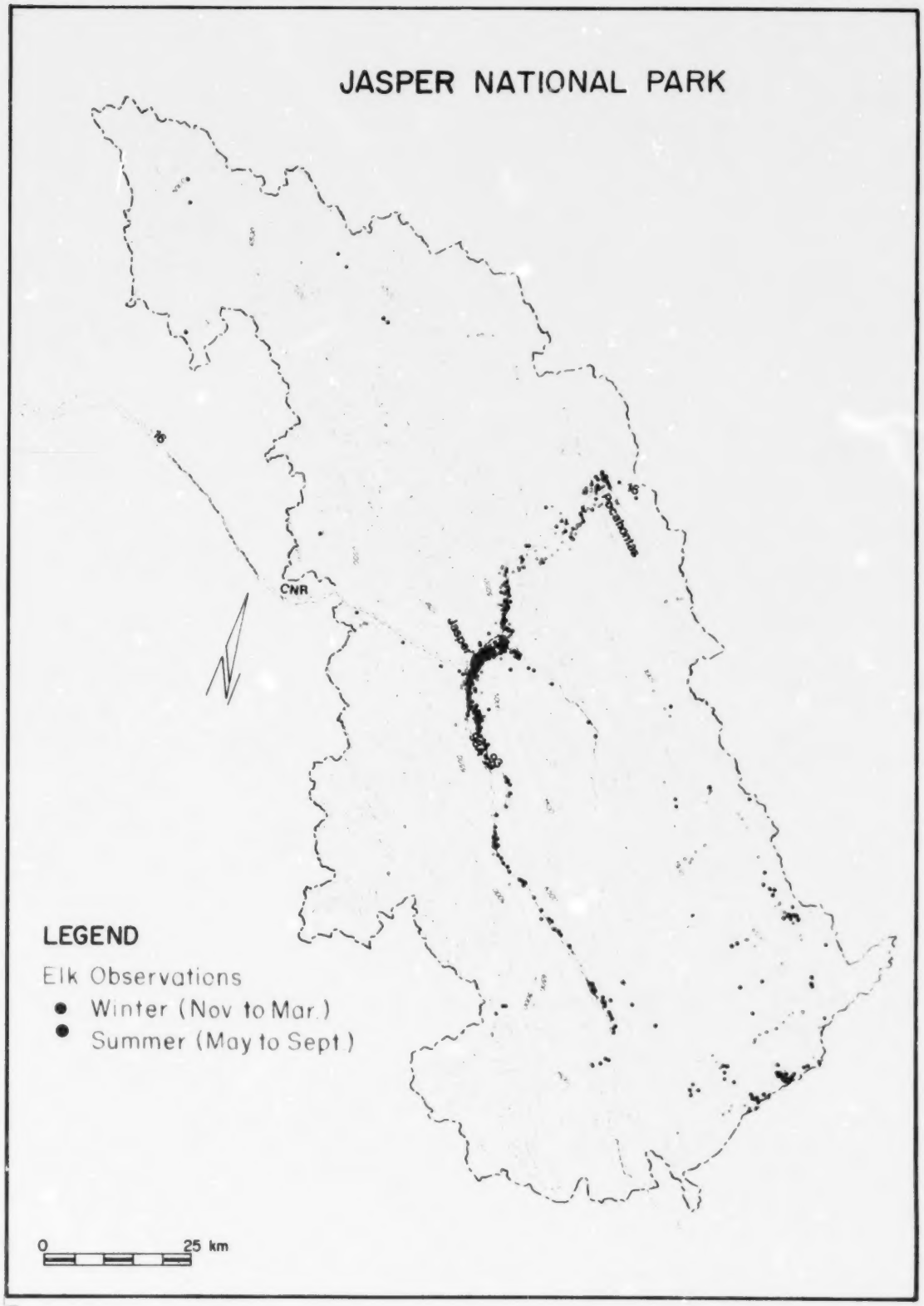


Figure 3.49. Distribution of elk observations in Jasper, summer and winter.



substantial population declines in some herds.

Elk are now widespread in both Banff and Jasper. They occur most commonly in the Front Ranges, however they are present throughout both parks in summer (Figures 3.48, 3.49). In winter elk are much more restricted, occurring mostly in the low-elevation valleys of the Front Ranges. The largest winter populations recorded are in the Athabasca River, Cascade fire road, Rocky River and lower Bow River valleys and the Brazeau River watershed (Table 3.34). The estimated population of elk in Banff from 1975-77 was 1,000 (Jacobson 1977). The 1961-73 population in Jasper was 1,975-2,375 animals (Stelfox et al. 1974).

Not all of the elk that summer in the parks winter there, and vice versa. Little is known about the movements of elk into and out of the parks. Some that summer in Yoho National Park winter in Banff (McCrory and Blood 1978), while some that summer in Banff winter in Kootenay (T. Gibbons, Warden Service, Kootenay National Park, pers. comm.) or in Alberta provincial lands.

HABITAT

In summer, elk are widely distributed and use a variety of habitats. They occupy all 3 ecoregions, however their use of the alpine is limited (Figure 3.50). There were 71.98 pellet groups/ha in the montane, 68.98/ha in the lower subalpine, 66.75/ha in the upper subalpine and 32.43/ha in the alpine ecoregion. During this inventory there were only 24 observations of elk in the alpine, 19 of which were in July and August.

Preferred elk summer habitats fall into two broad categories: alluvial ecosites with moist herb or willow vegetation or deciduous forest, and open avalanche slopes or steep, rocky ecosites having coniferous forests with herbaceous or shrubby understories or clearings (Table 3.35).

Elk use open forests, shrublands and meadows in the montane, lower subalpine and upper subalpine ecoregions more frequently than closed forests or alpine habitats.

Spruce/fir forest, heath and alpine vegetation receive low use by elk during the summer, comprising 58% of the vegetation types of moderate or low importance to elk (Table 3.37). Moist to wet upper subalpine Engelmann spruce-subalpine fir forests are exceptions however, being important elk summer habitat.

Elk generally feed on open slopes and alluvial areas during the early morning, evening and night, and bed in closed forests during the day. Well-drained subalpine avalanche slope grasslands are heavily used in summer and are of very high importance to elk. McCrory and Blood (1978) also found slide paths to be an important habitat in Yoho National Park, particularly for herds occupying tributary valleys. Stelfox (1974) found that elk are commonest of west, east or south-facing slopes during summer in Jasper.

During the rut, elk show a marked preference for forested areas. Of 49 observations of elk in the rut (bugling, sparring etc.) 39 (80%) were in forest, 31 (63%) in closed coniferous forests and 8 (16%) in open forests. Grasslands and shrub thickets accounted for the remaining ten rut-associated records.

Rutting activity was observed in the montane 16 times (33%), lower subalpine 22 (45%) and upper subalpine 10 times (20%).

Being primarily grazers (Kufeld 1973, Cowan 1947b), elk usually winter in areas with low snow accumulation, generally montane and lower subalpine valley bottoms and windblown slopes in the subalpine ecoregion (Table 3.36). In winters of light snowfall, elk inhabitat larger areas, often similar or close to their summer ranges, whereas in heavy snowfall winters, available winter range is limited and a distinct movement from summer to winter ranges may be observed. The altitudinal distribution of elk varies with the depth of snow.

Table 3.34. Largest elk herds recorded in Banff and Jasper between 1975 and 1980. Data from wildlife inventory files and warden wildlife cards.

Banff	
Lower Bow drainage	82
Middle Bow drainage	25
Lower Spray drainage	55
Panther drainage	50
Cascade drainage	135
Baker Creek drainage	9
Lower Red Deer drainage	12
Clearwater drainage	30
Jasper	
Lower Athabasca drainage	125
Middle Athabasca drainage	128
Lower Brazeau drainage	27
Isaac Creek drainage	32
Miette drainage	63
Moosehorn Creek drainage	47
Rock Creek drainage	25
Lower Rocky drainage	83
Lower Snake Indian drainage	58
Middle Snake Indian drainage	52
Townsite area	88

The importance of the montane ecoregion to elk in winter is revealed by the fact that there were 70.3 elk tracks/10km-day of track transects (81.1%) in the montane ecoregion, 13.3 tracks/10km-day (15.4%) in the lower subalpine ecoregion and 3.1 tracks/10km-day (3.6%) in the upper subalpine ecoregion. Similarily, 11 out of 17 ecosites (65%) ranked as important winter elk habitat on the basis of winter tracking data are montane.

Seventy per cent of the vegetation types ranked as important elk winter habitat by winter tracking and winter pellet group densities are montane (Table 3.110). By far the most important winter vegetation types for elk are montane grasslands and open, grassy lodgepole pine forests. Mixed poplar/coniferous forests are also heavily used.

Mature Engelmann spruce/horsetail/feathermoss (C32) forests are not used as heavily as Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30) or mixed aspen/coniferous forests. Heath vegetation, upper subalpine and alpine vegetation receive low use by elk in the winter.

Elk which remain in lower and upper subalpine areas in winter are predominantly (56%, n=16) small groups of mature bulls. These groups are usually found on windblown slopes or open alluvial meadows. Cow, yearling and calf groups concentrate in montane valley bottoms in winter, remaining separate from the mature bulls after the rut.

Elk occur throughout a wide range of snow depths, 1 to 95 cm. Peaks of intensity of use were recorded at the following depths: 17% at 1-5 cm, 10% at 21-25

Table 3.35. Highly important spring and early summer ecosites for elk, based on pellet group data.

Ecosite	Pellet groups/ha	Ecoregion	Parent material	Vegetation
EG2	320.0	upper subalpine	glacial till	larch-fir forest
GT2	255.7	lower subalpine	glacial till	dry pine forest and grassland
PP7	247.1	lower subalpine	alluvium	birch-willow scrub
HD4	200.0	montane	alluvium	grassland: scattered pines
AT1	172.5	montane	glaciofluvial	lodgepole pine forest
AL1	153.3	lower subalpine	alluvium	lodgepole pine forest
GT1	146.7	lower subalpine	glacial till	open coniferous forest
SF1	138.8	upper subalpine	glacial till	spruce-fir forest
BK4	138.2	lower subalpine	ice-contact drift	lodgepole pine forest and spruce bog
GA1	133.3	montane	landslide	lodgepole pine forest
CN1	131.7	upper subalpine	alluvium	willow scrub
NY1	130.0	montane	glacial till	Douglas fir forest
WF7	128.4	upper subalpine	colluvium	grassland
TR1	127.4	upper subalpine	glacial till	willow scrub
EN3	120.0	upper subalpine	colluvium	open coniferous forest
HC4	120.0	lower subalpine	alluvium	willow bog: sedge fen

and 10% at 56-60 cm. Most (85%) elk tracks were in snow less than 60 cm deep.

Stelfox et al.(1974) found that elk in Jasper occur most commonly on S or W facing slopes during the winter.

Dispersal onto summer range is dictated by growth and development of grass, sedges and forbs (Dalke et al. 1965a). During the spring, elk are most commonly found on W, E or S facing slopes (Stelfox et al. 1974) where snowmelt and green-up occur earliest.

LIFE HISTORY

Food habits

Ungulates in temperate environments are subjected to seasonal changes in the quality of food resources. In the spring or early summer the diet is most nutritious, however its quality decreases rapidly as the quantity of forage nutrients decreases during

Table 3.36. Highly important late summer, autumn and winter ecosites for elk, based on pellet count data.

Ecosite	Pellet groups/ha	Ecoregion	Parent material	Vegetation
HD4	1885.7	montane	alluvium	grassland; scattered pines
TA2	1654.6	montane	silt (eolian)	grassland
DV1	1451.4	montane	dunes	grassland; clumps of spruce
AT3	1400.0	montane	glaciofluvial	grassland; scattered pines
PP7	1127.1	lower subalpine	alluvium	birch-willow scrub
HD2	1023.8	montane	alluvium	open spruce forest
GT2	855.7	lower subalpine	glacial till	dry pine forest and grassland
DV2	720.0	montane	dunes	spruce forest
NY1	590.0	montane	glacial till	Douglas fir forest
NY3	525.2	montane	ice-contact drift	Douglas fir forest
VL4	466.7	montane	alluvium	spruce forest
SB5	483.6	lower subalpine	colluvium	grassland
VL5	506.7	montane	alluvium	willow thicket
AT1	465.0	montane	glaciofluvial	lodgepole pine forest

summer and autumn (Hobbs et al. 1979). Although diet quality continues to decrease during the winter, it does so at a reduced rate, and elk can offset the loss of forage quality by eating more shrub stems and poplar bark.

In winter elk concentrate on either grasses or shrub browse depending on their availability. Cowan (1947b) found that in Jasper during the winter, grass can account for as much as 97% of elk diet, with browse comprising the remaining 3%.

Stelfox et al. (1978) found that in May elk along the Medicine Lake delta were feeding on *Equisetum*, *Carex* and *Festuca* species. During the summer, elk occupying the higher elevations of the Brazeau Ranges preferred *Carex*, *Festuca*, *Salix*, *Astragalus*, *Potentilla*, *Equisetum*, and *Cladonia* species.

Information pertaining to food habits of elk in Banff and Jasper is very limited, however general information regarding Rocky Mountain elk may be obtained from Kufeld (1973).

Rut

The rutting period for elk varies slightly from year to year, however it is during September that it reaches its peak intensity (Figure 3.51). The earliest date when bugling was recorded was 4 August 1979 (JRA) in the lower Brazeau River valley, with 11 October 1978 being the latest recorded observation of rut-related behaviour (Warden files), in the middle Bow River valley.

After the rut, adult bulls leave the cow/calf/yearling herds and move to their wintering grounds, remaining separate from the other age/sex classes for the rest of the

Figure 3.50. Habitat use by elk, based on pellet group densities.

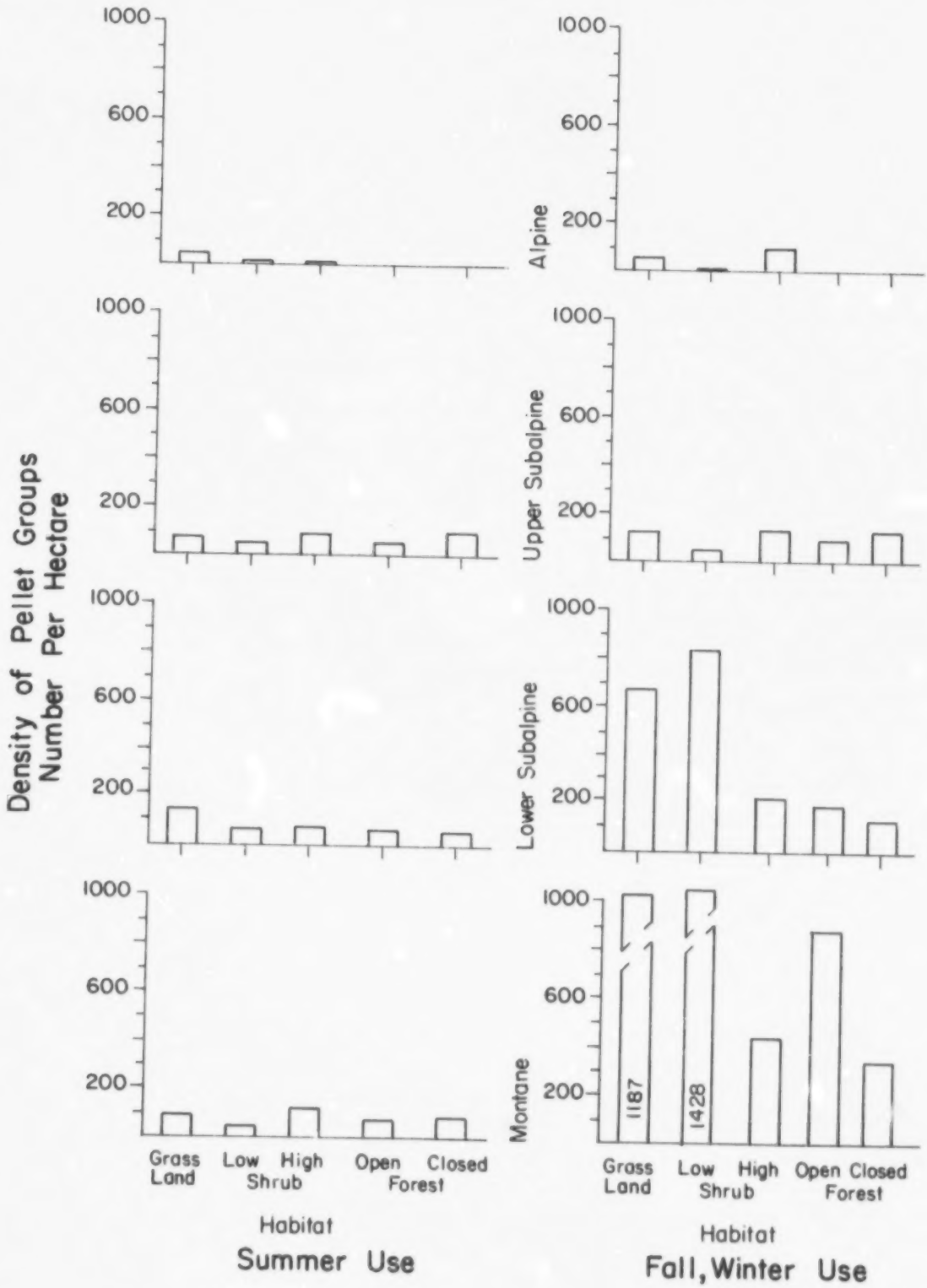


Table 3.37. Highly important spring and early summer vegetation types for elk, based on pellet group data.

Description	*Vegetation type*
Sedge-lousewort-bistort wet meadow	H3
Hairy wildrye-junegrass grassland	H14
Willow/horsetail shrub thicket	S7
Dwarf birch-shrubby cinquefoil/needlerush shrub fen	S3
Lodgepole pine/buffaloberry/showy aster closed forest	C6
Lodgepole pine/juniper/berry closed forest	C3
Lodgepole pine-spruce/buffaloberry/grouseberry	C18
Engelmann spruce-subalpine fir/rock willow/white heather closed forest	C24
Engelmann spruce-subalpine fir/grouseberry closed forest	C15
Needlegrass-oatgrass-fescue grassland	H13
Junegrass-everlasting-wild blue flax grassland	H6
Engelmann spruce-subalpine fir/rock willow open forest	O12, O14
Engelmann spruce-subalpine fir/willow/hairy wildrye open forest	O18
Subalpine larch/chalice flower-everlasting closed forest	C23
Subalpine larch/heather open forest	O13
Balsam poplar/buffaloberry closed forest	C17
Aspen/prickly rose/berry open forest	O1
Aspen/hairy wildrye-yellow peavine forest	C16
Willow-dwarf birch/fleabane shrub meadow	S4
Willow/hairy wildrye shrub meadow	S12
Barratt's willow/cinquefoil shrub meadow	S8
Dwarf Birch-willow/*Kobresia*-fescue shrub meadow	S9

year (Peek and Lovas 1968, Flook 1970).

Calving

The gestation period of elk is approximately 256 days and the mean birth date of the calves is 2 June (Flook 1970) throughout the area along the Red Deer valley. Traditional, localized calving areas have not been observed.

Lick use

The use of mineral licks by elk in Banff and Jasper is restricted to the summer. Dalke et al. (1965b) found that elk use of salt is greatest in May and June. In Willow Creek, Carbyn (1974b) found elk use of licks to be greatest in May and early June, before parturition. In Jasper the use of licks decreased after early June, when newborn calves were observed.

Stockstad et al. (1953) found sodium to be the element attracting ungulates to licks. Dalke et al. (1965b) feel that a 'salt hunger' may develop after feeding upon succulent spring vegetation.

Productivity

Productivity of various herds in Banff and Jasper has been determined by means of roadside surveys or published studies (Table 3.111). Productivity values for a hunted herd is Utah are included for comparison. Productivity of elk in Banff determined over the 5 year period 1975-1980 (September-November from warden files) is 18.2

Table 3.38. Highly important late summer, autumn and winter vegetation types for elk, based on pellet group data.

Description	*Vegetation type*
Wheatgrass-pasture sage grassland	H7
Needlegrass-oatgrass-fescue grassland	H13
Juniper-wheatgrass-blue flax-pasture sage grassland	H19
Shrubby cinquefoil/fleabane-blue flax dry slope	L1
Creeping juniper-wheatgrass dune grassland	L6
June grass-everlasting-wild blue flax grassland	H6
Lodgepole pine/juniper berry closed forest	C3
Lodgepole/pine/buffaloberry/showy aster closed forest	C6
Douglas fir/hairy wildrye closed forest	C1
Douglas fir/juniper-bluebunch wheatgrass open forest	O5
Balsam poplar/buffaloberry closed forest	C17
Aspen/hairy wildrye-yellow peavine forest	C16
Hairy wildrye-junegrass grassland	H14
White spruce/shrubby cinquefoil/berry open forest	O3
White spruce/juniper-berry open forest	O17
Willow/horsetail shrub thicket	S7
Dwarf birch-shrubby cinquefoil/needlerush shrub fen	S3
White spruce/twining honeysuckle closed forest	C2
White spruce/prickly rose-twinflower closed forest	C27
White spruce/buffaloberry closed forest	C26
White spruce/arrowgrass-sedge bog forest	O7
Engelmann spruce-subalpine fir/rock willow open forest	O14
Sedge-lousewort-bistort wet meadow	H3
Dwarf birch-willow/Kobresia-fescue shrub meadow	S9

young/100 cows. The value for Jasper for the same period was 30.4 young/100 cows.

Mortality

Railroad and roadkills are the major factors contributing to elk mortality in both Banff and Jasper National Parks. In Banff warden Halle Flygare has monitored road and trainkills since 1964; prior to this time data are sketchy. For example from 1945 to 1963 214 trainkills and 29 roadkills were recorded; however from 1964-1980 there have been 247 trainkills and 415 roadkills recorded. In Jasper there were 283 roadkills and 226 trainkills reported from 1975-1980.

Railway and roadkills contribute the most to elk mortality, followed by predation (Tables 3.40, 3.41). In Jasper wolves are the major predator of elk, followed by grizzly bears. In Banff wolves are not as important as in Jasper however this is probably due to their scarcity in this park. Cougars and grizzly bears are the other major predators of elk in Banff and Jasper.

MANAGEMENT HISTORY

Elk have been more intensively managed and studied in the Rocky Mountain national parks than any other ungulate species.

The apparent extirpation of elk in the Alberta Rockies at the turn of the century led to interest in re-establishing the species in Banff and Jasper. Re-introduction of elk from Manitoba in 1900 and from Wyoming in 1917, 1918 and 1920 (see above) was successful and the imported animals bred prolifically with native elk that had survived in

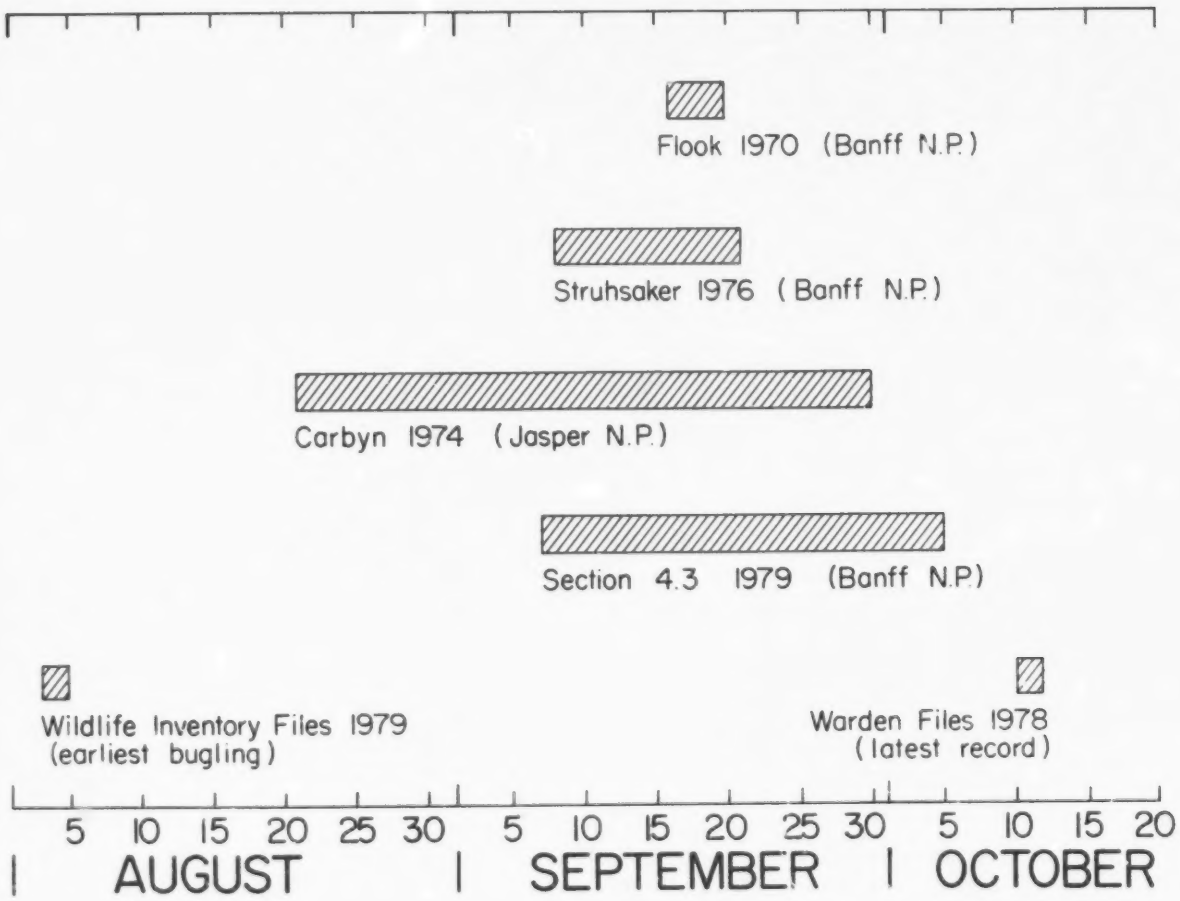


Figure 3.51. Elk rutting dates in Banff and Jasper.

Table 3.39. Elk productivity rates recorded in Banff and Jasper

Dates	Location	YOY/ 100 F	Reference
Nov. 1979	Banff (Cascade valley)	22	sec. 4.2.3; this report
Jun. 1978 to Feb. 1979	Jasper (Athabasca valley)	24	sec. 4.2.4; this report
Sep. 1978	Banff (Red Deer valley)	31	Morgantini 1978
Nov. 1976	Banff (Bow valley)	63	Holroyd 1976
Winter 1974	Jasper (Willow Creek)	56	Carbyn 1974b

B.C. and the Brazeau valley. Subsequent censuses indicate that some native elk must in fact have been present since elk numbers increased at greater than the maximum potential rate of increase. Chief Game Guardian Sibbald of Rocky Mountain National Park (later Banff) felt that elk were already entering the park from B.C. in 1916 and that, given time, they would re-introduce themselves (National Archives, Ottawa).

The re-introduction may not have been necessary but it was certainly succesful. The hybrid elk flourished and spread to occupy all areas they had previously occupied. By 1925 they were creating problems in Banff townsite and wardens were shooting them with shotguns loaded with salt to keep them off the streets and golf course. The problems persisted and led to the eventual fencing of the golf course and regular "elk patrols" of the townsite (Banff park files).

In 1932 there was correspondence between Banff superintendent Jennings and the CPR concerning elk mortality on the railroad. The superintendent reported that 18 had been killed in 1929, 12 in 1930, 10 in 1931, and 121 in 1932. This was the first documentation of wildlife mortality on transportation corridors, a problem that became more severe in the 1970's and 1980's as traffic increased and habitat change led to elk concentrations on roadsides.

By the late 1930's elk were abundant in all parts of Banff and Jasper except along the continental divide (Anderson 1938, Clarke 1940,1942). Although Special Wildlife Warden Green expressed skepticism of biologists who made management recommendations based on short visits to the parks (Banff warden files), a series of reports by Clarke (1940, 1942) and Cowan (1943, 1944, 1945, 1946a,b) documented range deterioration on elk winter ranges and recommended that controlled elk slaughters be conducted in Banff and Jasper.

The 1940's marked the beginning of a period of intensive range management focussing on elk and, to a lesser extent, bighorn sheep. Elk censuses were initiated, range exclosures were built, and data on browse utilization and forage carryover were gathered. The matter of elk competition for forage with bighorn was a major factor in the decision to slaughter elk (Green 1949, Tanner 1950).

Slaughters were initiated in Banff in 1941 and by the time they ceased in 1969 at least 3,923 elk had been slaughtered with a maximum kill of 352 in 1946. In Jasper at least 2,100 elk were killed between 1945, when 197 were reported shot, and 1970 when 300 were killed. Hides and carcasses were for the most part distributed to Indian communities in Alberta. Elk were also slaughtered for meat for prisoner-of-war camps during the earlier years (correspondence between Controller Smart and Banff Superintendent Jennings, Banff warden files).

Table 3.40. Causes of elk mortality in Banff and Jasper National Parks (from park wildlife cards, 1945 to 1980).

Cause	Banff	Jasper	Total
Road kills	444	282	727
Railroad kills	461	226	687
Malnutrition/starvation	16	32	48
Disease	2	1	3
Avalanches	9	-	9
Intraspecific aggression	3	4	7
Poaching	12	30	42
Predators	47	94	141
Unknown	37	108	145
Drown	-	7	7
Accident[0]	-	3	3
Totals:	1,031	788	1,819

[0]including falls, tangle in wire and tranquilizer overdose.

Public criticism of the slaughters led to the termination of the control program in the late 1960's. In 1971, 56 elk were trapped in Banff and shipped to Paulson B.C. for introduction to unoccupied range and it was noted that "the public is behind this type of live elk shipping program as against heavy criticism of elk reduction slaughters" (Banff park files).

That the need for elk slaughters was debatable is suggested by a memo from Jennings to Smart in 1942 noting that there were very few elk in the Bow valley, partially because of the "extraordinary feed available everywhere". He added, "I would not recommend a continuation of the elk slaughter again this winter." Green (1946 memo to Controller Smart) asked for reconsideration of that year's directive to remove 500 elk from the Bow valley west of Banff as he doubted that there were 500 there and felt slaughters should be based on more up-to-date surveys.

The perceived over-population of elk in Banff and Jasper was no doubt largely a result of the abundance of early-successional vegetation in areas that had been burned in the late 1800's and early 1900's. These areas gradually succeeded to dense lodgepole pine forest, becoming progressively less productive of forage (Stelfox 1972). By the 1970's the potential capacity for the parks to support elk was much reduced. Where slaughters had been considered necessary to reduce numbers of elk ten years previously, concern was being expressed by the late 1970's that elk were declining.

The major factor implicated in the decline of elk in the Athabasca and Bow valleys was excessive mortality on roads and railroads (Flygare 1978, Holroyd 1979a, Van Tighem 1980).

A memo from the Banff Superintendent to the Parks Controller in 1960 stated that elk were being killed more frequently on the trans-Canada highway since the roadside seeding program had begun. Increasingly during the subsequent years the high-quality pasture mix used to stabilize road cuts became a major food source as forest replaced open burns and as grasslands -especially in Banff - were developed for human use.

Table 3.41. Sources of elk predation in Banff and Jasper National Parks (from park wildlife cards, 1945 to 1976).

		Elk killed (by age/sex class)					
Predator	**Park**	**M**	**F**	**YOY**	**YLY**	**UNK**	**Total**
Wolf	B	3	1	3	2	7	16
	J	9	13	8	2	4	36
Coyote	B	0	0	0	0	0	0
	J	0	0	1	0	0	1
Dog	B	1	0	0	0	0	1
	J	0	0	0	0	0	0
Grizzly	B	2	1	0	1	3	7
	J	1	3	1	1	1	7
Cougar	B	3	0	2	4	3	12
	J	0	0	0	1	0	1
Wolverine	B	0	0	0	0	0	0
	J	0	0	0	1	0	1
Unknown	B	4	1	0	0	5	10
	J	0	0	0	0	0	0
Totals		23	19	15	12	23	92

B=Banff
J=Jasper

Studies of wildlife mortality on the trans-Canada highway in Banff (Flygare 1978 1979; Holroyd 1979a) led to the inclusion of fences and underpasses in the highway twinning program begun in 1981. In Jasper the twinning of the CNR line afforded Parks Canada with an opportunity to require CN Rail to cover coarse fill with fine material to allow elk to escape approaching trains (Van Tighem 1980; J. Woodrow, Jasper warden service, pers. comm.).

MANAGEMENT CONSIDERATIONS

The damage caused to elk populations by railroad and highway mortality in the Bow River and Athabasca River valleys cannot be over-emphasized, particularly in light of the fact that these two areas represent the wintering ranges of more than half the elk of Banff and Jasper. Holroyd (1979a) indicated that the levels of mortality between 1976 and 1978 (30 to 66 elk per year) in the Bow valley could ultimately cause elk to be extirpated from that drainage. Subsequently, mortality increased to 68 in 1979 and to 104 in 1980. The severity of the problem in the lower Athabasca River and Miette River valleys is less well-documented but no less important. As traffic volumes increase and as major transportation arteries in the montane ecoregion are enlarged, this problem has the potential of becoming the single most severe impact of humans on the wildlife in Banff and Jasper. Effective measures such as those discussed by Flygare (1979) must be implemented to eliminate or effectively reduce unnatural mortality of elk or highways and railroads.

The montane ecoregion is of critical importance to elk wintering in Banff and Jasper. This ecoregion however, is also the site of the Banff and Jasper townsites,

major highways, railroads and numerous tourist facilities. A continual loss of habitat in this ecoregion exists due to expansion of the townsites, resident and tourist facilities and twinning of highways and railroads. In Banff the montane ecoregion comprises only 2.86% of the entire park; 8% of this area has already been alienated by the townsite, tourist and resident facilities, roads and railroads (Holroyd and Markel unpub. data). Careful planning and consideration of alternatives is needed before any more of the montane ecoregion is developed.

Another habitat-related concern is that of fire suppression. It is present practice to extinguish all forest fires. Fire is a natural element that plays a role in maintaining vegetation diversity. Elk are losing important habitat such as grasslands and meadows, through natural succession to climax forests. Controlled burns would increase available habitat for elk.

Some of the elk in Banff and Jasper migrate out of the park into the province or into other parks. At this time very little is known about these movements. This information is important in terms of population dynamics, estimating increases or decreases in specific populations, and assessing the reasons for these. Elk movements can best be monitored by marking or radio-collaring elk on winter and summer ranges and monitoring their subsequent movements, as is currently being done by P. Jacobson of the Banff warden service.

With the growth in popularity of cross-country skiing and ski mountaineering, people are venturing into areas that were once undisturbed. As the winter is a critical season for elk unnatural stress should be minimized at this season. Recreational use of montane and Front Range valleys which contain important wintering habitat for elk will increase disurbance of elk. Winter wildlife photography should be discouraged and photographers educated as to their effects on wildlife during seasons of high stress.

WOOD BISON *Bison bison athabascae* BISO

STATUS AND DISTRIBUTION

Wood bison formerly occurred in both Banff and Jasper National Parks, but had been extirpated by the late nineteenth century. Today only a few skulls remain in remote valleys of both parks, and a small display herd that is maintained in an enclosure near Banff townsite.

Banfield (1958) reviewed the known history of wood bison in Banff from the first record in David Thompson's diary of bison in 1808 to the last known record of a bison killed in the Pipestone valley about 1858. Wood bison once occupied the Howse and North Saskatchewan valleys, the Bow River watershed including Simpson Pass, Pipestone River and other side valleys. Clarke (1940) found wallows and skulls in the lower Red Deer River, Clearwater River, Mistaya River and Spray River valleys, and Taverner found a skull in the Cascade valley.

The historical status of wood bison in Jasper was reviewed by Soper (1970). Bison occurred in the Athabasca valley and were evidently common enough that an area near Wabasso Lakes came to be known as Prairie de la Vache (Buffalo Prairie). Clarke (1942) saw bison skulls along the Brazeau River and a wallow near Devona and felt that bison had probably ranged up the Snake Indian River.

Bison had disappeared from Jasper by the 1850's, as well as from other areas to the north and east (Soper 1970, Dawson 1881) although a fewsurvived intothe 1880's locally in the foothills (Stelfox 1972). The causes of this early extirpation in the Rockies are not known, but hunting and disease certainly were contributing factors. An epidemic was reported by Indians to have killed many bison in 1847 along the North Saskatchewan

River (Spry 1968). Moberley (1884) attributed the disappearance of bison to "... Indians after the introduction of firearms". In the same report he describes white hunting parties of more than 150 members; doubtless these played as great a role as did Indians.

Whatever the causes, Hollister (1912) reported that "Mr. Lewis Swift told me that at the time he came into this country [the Athabasca valley] some seventeen years ago, the oldest Indians could not remember the living buffaloes. People then seventy-five years old knew nothing of the animals beyond the fact that the bleached skeletons were there". In the North Saskatchewan valley, where Thompson had found bison numerous fifty years earlier, James Hector found only dung (Spry 1968) while that same year the Earl of Southesk (1875) saw only "wallows on the Kootenai Plains". By 1860 the wood bison was gone.

In 1897 the plains bison arrived. A bull and two cows were donated to the new Rocky Mountain Park by a Toronto lawyer. These were placed in a fenced enclosure for viewing by the public and were joined the following year by thirteen more bison donated by Lord Strathcona (Ogilvie 1979). This enclosed bison herd remained a major tourist attraction for the next 80 years.

In 1981 the plains bison were removed from the Banff enclosure and replaced with a small wood bison herd. This exchange was part of a program by the Canadian Wildlife Service to establish wood bison herds in enough locations to ensure the survival of the subspecies (H. Reynolds, Canadian Wildlife Service, pers. comm.).

HABITAT

Little is known of the habitat needs of wood bison because of the scarcity of natural herds. The Jasper herd (see below, Management) remained in lower subalpine grasslands for only two or three days in mid-summer before moving to an alpine basin at 2200 to 2400 meters elevation. One bull which remained in the park almost two years wintered in a tall willow thicket on an alluvial site in the montane ecoregion. Two bison spent part of the summer of 1979 in upper subalpine open forest near Utopia Lake.

Two skulls found by inventory staff in 1979 in the Clearwater valley further indicate that wood bison are not restricted to low elevations in the mountains. Both were in the upper subalpine ecoregion, one in an open spruce-subalpine fir forest (O10) and one in an alluvial shrub meadow (S8).

Elsewhere, wood bison frequent mixed forest, sedge meadows and grasslands (Banfield 1970).

MANAGEMENT CONSIDERATIONS

The wood bison is considered a threatened subspecies by the Committee on the Status of Endangered Species in Canada (COSEWIC), with free-roaming wild populations occurring only at Elk Island National Park and in the Fort Providence area, near Great Slave Lake (Davidson and Norcross 1978). The latter population is threatened by disease, wolf predation and hunting (H. Reynolds, pers. comm.). In order to protect the subspecies from catastrophic events it is considered essential that at least six different free-roaming wild populations be established in different parts of their former range. Two attempts have been made thus far, one in Jasper and one in Nahanni National Park. Only the latter was relatively successful (H. Reynolds, pers. comm.).

On 8 and 9 July 1978, twenty-eight wood bison were moved into the Willow Creek area of northern Jasper and held in a paddock until 22 July, when the 27 survivors were released into the wild. This joint project of Canadian Wildlife Service and Parks Canada, however, was unsuccessful. After about a week in the park 21 animals moved north and by 26 August they were feeding in a hayfield 20 km. southwest of Grande Prairie. Eighteen were re-captured and the survivors returned to Elk Island National Park.

Six bison remained in the park but at least two were killed by a train and one hit by a truck in the lower Athabasca valley the following year and none could be located by summer 1980.

The re-introduction attempt improved the state of knowledge of problems with and approaches to introducing bison to the wild. The possibility remains that once the methods have been perfected, wood bison may again be returned to the wild in Jasper National Park.

The major cause of the original extirpation of bison from the mountains and foothills of Alberta will probably always be unknown. An epizootic may have been involved, since bison from so vast a territory were decimated.

The wide-ranging nature of wood bison requires that further attempts to re-introduce them take place after agreements with neighboring jurisdictions have been made.

MOUNTAIN GOAT *Oreamnos americanus*

STATUS AND DISTRIBUTION

Mountain goats are restricted to the mountainous regions of northwestern North America with a small introduced population in the Black Hills of South Dakota. In Canada goats occur in British Columbia, Alberta, and the Yukon and Northwest Territories.

An estimated 1200 goats inhabit the Rocky Mountains and foothills of Alberta outside the national parks, with half of these occurring in the Willmore Wilderness north of Jasper (Hall 1977). Other goat concentrations are in the Whitegoat and Siffleur Wildernesses and the Kananaskis, Elbow, Sheep and Highwood River drainages. In Jasper there are believed to be at least 500 (Woodrow 1979, Jasper warden file #9810-8-2). In Banff there may be more than 1000 (Jacobson 1977).

Mountain goats were present in "most of the higher ranges on both sides of the main divide" and "really common... around the head of the Smoky River in 1911" (Hollister 1911). They were "... everywhere present along the east slope in numbers... well up in the thousands" (Millar 1915) and "... increasing in numbers in Rocky Mountain Park where they may be found in nearly all parts of the park" (Williamson 1916).

Millar (1915) painted a dismal picture of ungulate decimation throughout the Rockies but was nonetheless able to state that goats were abundant. Although Millar may have somewhat overstated the abundance of the species, it was evidently still common at a time when other species were badly depleted. The success of goats may partly have been a factor of habitat stability, since goats tend to frequent areas of climax vegetation and steep broken terrain where severe winters are unlikely to result in deep snow accumulation. Goats were also more isolated than other ungulates from domestic livestock and their exotic diseases. Soper (1970) attributed the stability of goat populations to the difficulty of hunting them compared to species frequenting lower, less rugged terrain. The Earl of Southesk's hunting party killed more than 35 sheep on their hunting trip through the Rockies; in spite of his great desire to get a goat Southesk only succeeded in shooting two near the end of his trip by nearly killing himself (Southesk 1875). Nonetheless, certain goat populations were subject to over-hunting. Lewis Swift told Hollister (1912) that he had "... killed many on Pyramid Peak", where goats remain uncommon today.

Within Banff and Jasper National Parks the distribution of goat populations have not changed noticeably from those described by Clark (1940, 1942), Cowan (1943, 1944, 1946a,b), Banfield (1958) and Soper (1970). Banfield (1958) showed that goat numbers

and distribution were similar to those described by early park investigators, and Jacobsen (1977) stated further that "Favorite haunts of the goat recorded in the early nineteen hundreds are still inhabited by fair numbers of goats today". In Alberta generally, however, goats inhabit only about 70% of their historic range (Johnson 1977).

Mountain goats occupy every mountain massif in Banff and Jasper. Populations tend to be larger in the Front Ranges than they are in the Main Ranges where there is less suitable range (Table 3.42). The northeastern corner of Jasper supports especially high numbers of goats.

In Banff the largest populations occur on:
- Wilson Range, including Mts. Wilson, Coleman and Cirrus, and Parker's Ridge
- Dormer Pass and north Stoney Creek area
- Flint Peak and adjacent mountains
- Goat Range (east of Spray River)
- Slate Range (east of Lake Louise)
- Peters and Divide Creek watersheds

In Jasper the largest populations occur on:
- Laura Pass/upper Moosehorn Creek
- Mount Kerkeslin
- Persimmon Range (near Rock Creek)
- Mount Kelsey and the Ancient Wall
- Desmet Range
- Mount Charlton and the Maligne Range
- Portal Creek/Whistler Pass
- Le Grand Brazeau

HABITAT

Mountain goats are primarily a species of the upper subalpine and alpine ecoregions (Figure 3.52) inhabiting rugged terrain that is little used by other ungulates. Pellet group densities were highest in the alpine (53/ha) and upper subalpine (50/ha) and considerably lower in the lower subalpine (19/ha) and montane (4/ha) ecoregions.

Within the alpine and subalpine ecoregions, goats are commonest on grasslands and low shrub meadows. Coniferous forests are used less frequently. Goats are also common on low shrub meadows on steep south facing slopes in the montane ecoregion.

The relative degree of use of the lower and upper subalpine ecoregions appears to vary among goat populations depending on local conditions. During regular surveys of Mount Kerkeslin (section 4, below) 74% of all winter goat sightings were in the upper subalpine and 26% in the lower. On Mounts Coleman and Wilson in Banff, however, 96% of all winter goat sightings were in the lower subalpine. Almost half - 47% - of all summer goat sightings on Mt. Kerkeslin were in the upper subalpine, while only 10% of summer goat sightings along the Banff survey route were there.

Use of the alpine ecoregion also varies among populations. Alpine range is important to populations on the Slate Range, (Jacobson and Loewen 1980), Parker's Ridge (Canadian Wildlife Service files) and Marmot Mountain (Park wildlife cards). Use of the montane ecoregion appears to be directly related to mineral lick use (Disaster Point, Shalebanks, Highway 93 Goat Lick Viewpoint) but while in the vicinity of Disaster Point goats forage on adjacent slopes.

Obviously, any generalizations about goat habitat must be qualified by the fact that each ungulate population has its own habitat-use pattern. Similarly, each population has its own "critical" habitats depending on which habitat factors are most limiting in its range. Nevertheless, some generalities can be made concerning habitat preferences. Ecosites

Figure 3.52. Habitat use by mountain goat, based on pellet group densities.

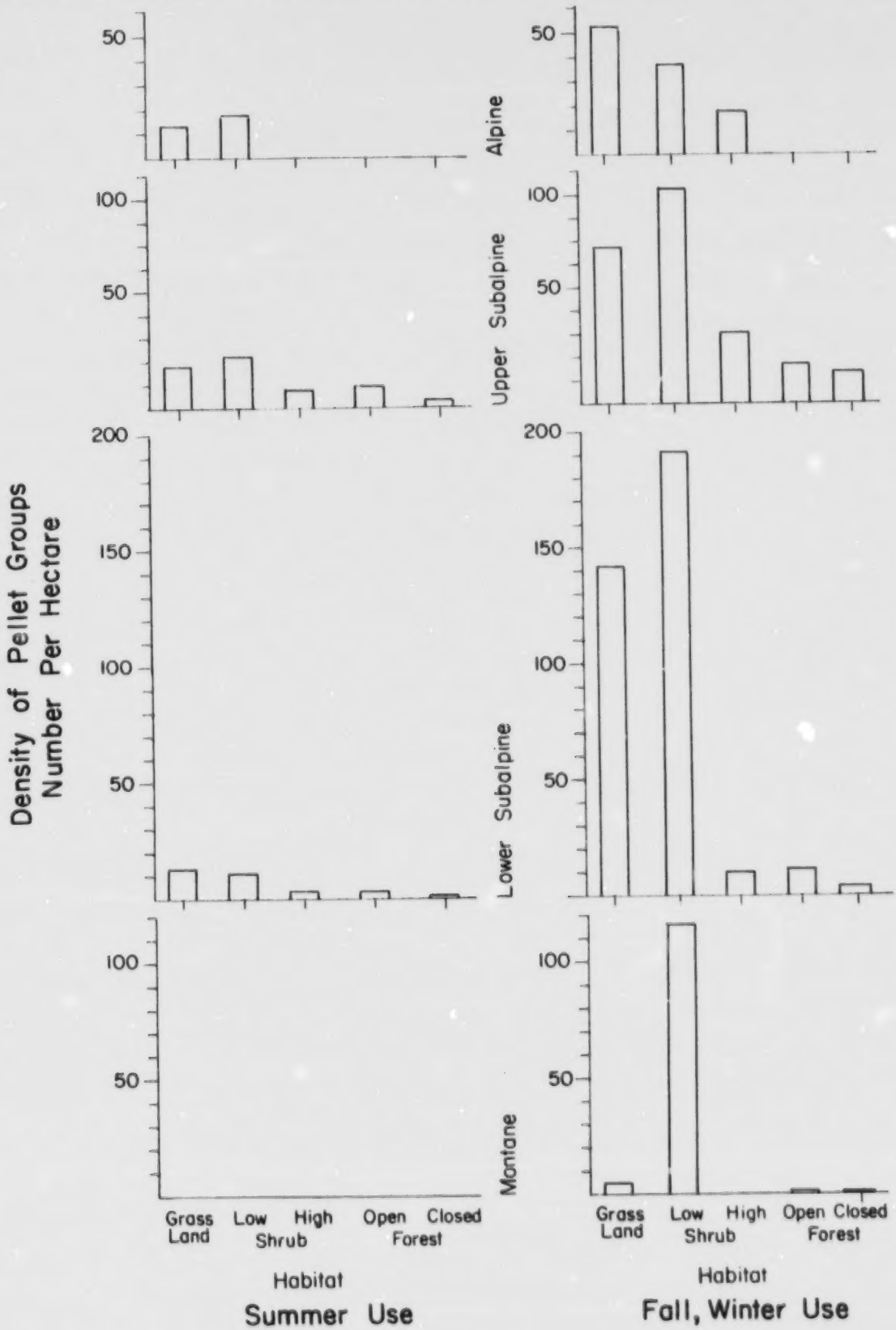


Table 3.42. Maximum single counts of mountain goats in Banff and Jasper since 1974.

Location	#	Reference
BANFF:		
Front Ranges		
Dormer Pass, N. Stoney Creek	87	Jacobson (1977)
Flint's Park, N. Cascade River	57	Jacobson (1977)
Peter's Creek	39	Jacobson (1977)
Main Ranges		
Wilson Range	85	this study
Slate Range	35	Jacobson and Loewen 1977
JASPER:		
Front Ranges		
Laura Pass, Upper Moosehorn Creek	66	park wildlife card
Persimmon Range, Rock Creek	43	park wildlife card
Poboktan Pass	40	park wildlife card
Mt. Charlton, upper Maligne River	37	park wildlife card
Mt. Kelsey, Ancient Wall	34	this study
Main Ranges		
Mount Kerkeslin	52	this study

most heavily used are colluvial slopes with mosaics of low shrubbery and meadows, especially in the upper subalpine ecoregion (Tables 3.43,3.44). Escape terrain in the form of broken cliffs is essential. Goats rarely stray far from cliffs except when travelling to licks. During hot days goats frequently use overhangs or small caves for shade, or lie on snowbanks. They are occasionally observed on glaciers. Unlike sheep, they make little use of talus.

Goat winter range is characterized by steep broken terrain with patches of windblown grassland interspersed with cliffs and avalanche paths. By taking advantage of localized wind conditions and terrain too steep to accumulate snow, goats are able to winter in areas where deep snow excludes other ungulates. Highest goat winter pellet group counts were on subalpine slopes exposed to avalanching (Table 3.43).

Climate has a considerable influence on goat distribution and habitat use, particularly in winter. Goats do not migrate to lower elevations but remain confined to small areas where wind and sun keep vegetation relatively snow-free (Table 3.44). Most winter goat ranges are on west- to south-facing slopes or ridgetops. Goats on the Palliser Range in Banff and Mount Kerkeslin in Jasper rely heavily on steep southwest-facing grasslands. On the Wilson Range, however, shrub thickets (often on avalanched tracts) receive highest use. Heath tundra on windswept ridges is the principal winter habitat on the Slate Range in Banff (Jacobson and Loewen 1980) and this herd also uses "scrub timber". Open forests are moderately important (20% of observations) on the Wilson Range.

In summer, goats occupy a wider range of habitats than in winter (Table 3.43, 3.46). Alpine meadows and open coniferous forests are used more heavily. The highest pellet counts were recorded on colluvial slopes with open forest, and on the Wilson Range 68% of summer goat observations were in open Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) forests. Favoured summer range on the Slate

Table 3.43. Highly important spring and early summer ecosites for mountain goats, based on pellet count data.

Ecosite	Pellet groups/ ha	Ecoregion	Parent material	Vegetation
RO0	552.0	various	rock	none
PL4	62.1	Upper Subalpine	till	open spruce-fir forest
WF2	61.7	Upper Subalpine	colluvium	avalanche shrub and herb complex
EN2	52.5	Upper Subalpine	colluvium	avalanche shrub and herb complex
SB1	46.2	Lower Subalpine	colluvium	avalanche shrub and herb complex
WF3	38.5	Upper Subalpine	colluvium	open mixed coniferous forest
EF1	35.4	Alpine	till	heath
RD1	31.1	Alpine	colluvium	heath or dryas tundra
WF4	28.6	Upper Subalpine	colluvium	spruce-fir forest
WF7	27.4	Upper Subalpine	colluvium	herb meadow

Table 3.44. Highly important late summer, autumn and winter ecosites for mountain goats, based on pellet count data.

Ecosite	Pellet groups/ ha	Ecoregion	Parent material	Vegetation
RO0	416.0	various	rock	none
SB1	351.3	Lower Subalpine	colluvium	avalanche shrub and herb complex
WF3	247.7	Upper Subalpine	colluvium	open mixed coniferous forest
EN2	220.0	Upper Subalpine	colluvium	avalanche shrubs and herb complex
EN1	180.0	Upper Subalpine	colluvium	spruce-fir forest
WF2	175.0	Upper Subalpine	colluvium	avalanche shrub and herb complex
PL4	126.9	Upper Subalpine	till	open spruce-fir forest
TA2	125.8	Montane	eolian	dry grassland and low shrubs

Range is alpine heath tundra (Jacobson and Loewen 1980).

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Table 3.45 Highly important late summer, autumn and winter vegetation types for mountain goat.

Description	*Vegetation type*
Hairy wildrye–wild strawberry–fireweed grassland	H5
Shrubby cinquefoil/bearberry–northern bedstraw dry slopes	L1
Juniper–willow shrub slope	L2
Mountain avens–*Kobresia*–bearberry grassland	H4
Hairy wildrye–junegrass–bearberry grassland	H14
Unspecified herb meadow	H17
Limber pine–Douglas fir/juniper bearberry open forest	O2
Bluebunch wheatgrass–hairy wildrye–showy aster grassland	H19
Heather–everlasting heath	L5
Mountain avens–snow willow–moss campion tundra	H1
Mixed coniferous open forest	O4

Table 3.46. Highly important spring and early summer vegetation types for mountain goats.

Description	*Vegetation type*
Hairy wildrye–junegrass–bearberry grassland	H14
Mountain avens–*Kobresia*–bearberry tundra	H4
Subalpine fir–willow avalanche scrub	S2
Juniper–willow·dry slope	L2
Heather–everlasting heath meadow	L5
Hairy wildrye–wild strawberry–fireweed grassland	H5
Shrubby cinquefoil/bearberry–northern bedstraw dry slope	L1
White mountain heather–mountain avens–snow willow heath meadow	L4
Mixed coniferous open forest	O4
Engelmann spruce–subalpine fir/heather open forest	O10

Food habits

Mountain goat food habits have not been studied in Banff and Jasper. Saunders (1955) studied their food habits in Montana. In summer 56% of their diet was grasses, including tufted hairgrass (*Deschampsia caespitosa*), sheep fescue (*Festuca ovina*) and alpine bluegrasses (*Poa* spp.), sedges and rushes. Forbs, including lupine (*Lupinus* spp.), *Mertensiana*, and *Polemonium* spp., comprised 24% of their diet. Woody shrubs comprise 16% of their diet, including *Vaccinium* spp., willows (*Salix* spp.) and currant (*Ribes* spp.). Shrubs were not eaten in winter but conifers became important, with Douglas–fir and subalpine fir comprising 25% of their diet.

Johnston et al. (1968) assessed the food value of alpine tundra plants and found that food value increases at higher elevations. McFettridge (1977) cites this as a partial explanation for the movement of goats to higher elevations in summer.

Reproduction

Table 3.47. Estimates of productivity of goat populations in Alberta and British Columbia.

Area	Period	Year	Kids/ 100 adults	Reference
BANFF				
Slate Range	winter	1979	18	Jacobson and Loewen 1980
Wilson Range	all year	1978/ 79	14	this study
whole park	all year	1945–76	11	park wildlife cards
JASPER				
Mount Kerkeslin	all year	1979/ 80	23	this study
whole park	all year	1945–76	17	park wildlife cards
Yoho National Park	autumn	1975–76	29	McCrory et al. 1977
Kootenay National Park	all year	1962–64	56	Holroyd 1967
Glacier National Park	all year	1977–78	29	McCrory 1979
Mt. Revelstoke National Park	all year	1977–78	17	McCrory 1979
East Kootenay Region	all year	1965–67	30	Hebert and Turnbull 1978
Wilmore Wilderness Park	all year	1973–75	31	McFettridge 1978

The rut is during November (Soper 1970), extending into early December (Petticrew and Munro 1979). During the rut, goats congregate on traditional ranges, but in considerably smaller numbers.

Young are born from mid–May to mid–June in Banff and Jasper, although there have been records of April births at the Ancient Wall and Parker's Ridge (Canadian Wildlife Service and park wildlife cards).

Goat productivity varies markedly from one study to another, probably due as much to the difficulties involved in censusing goats as to actual differences in productivity (Table 3.47). The estimates of the number of kids per 100 adults in Banff and Jasper are generally lower than in other areas. This may be because surveyors did not consistently produce good classified counts, particularly during the period 1945–1975 when there was no consistent reporting system.

Mortality

There were 40 cases of mountain goat mortality documented in Banff and Jasper between 1945 and 1980 (Table 3.48). Predation accounted for 10 of these cases occuring between November and April. Goats are most vulnerable to predation when travelling to and using mineral licks (McCrory 1965, Carbyn 1974b). There are also seven records of unsuccessful predation attempts (park wildlife cards) by coyotes (3), wolf (1), grizzly bear (1), black bear (1) and golden eagle (1). Predation is not a major source of goat mortality in most areas (Wigal and Coggins 1982). There were four recorded goat deaths on highways in the parks. Two trap deaths resulted from a trapping project to supply mountain goats to the Calgary Zoo in 1962.

Although only three goat deaths were definitely avalanche–related, several of the unknown mortalities may also have been caused by avalanches. Holroyd (1967) considered avalanches to be the major cause of goat mortality on Mount Wardle in Kootenay National

Table 3.48. Causes of mountain goat mortality in Banff and Jasper Parks, based on park wildlife cards.

Cause of mortality		Goats killed				
		BANFF		*JASPER*		
		A	**B**	**A**	**B**	**Total:**
Predator:	Cougar	1	0	0	0	1
	Wolf	1	0	0	0	1
	Grizzly	0	0	1	1	1
	Unknown	1	0	0	1	2
Avalanche		1	0	1	1	3
Road kill		0	1	1	2	4
Disease or old age		1	0	2	0	3
Trap death		2	0	0	0	2
Unknown		3	11	4	0	18
Totals		10	12	9	4	35

A 1947-1975
B 1976-1980 and CWS files.

[a]Carbyn (1974) recorded 3 cases of wolf predation.
McCrory (1965) recorded 1 case each of cougar and black bear predation.

Park.

Mineral Licks

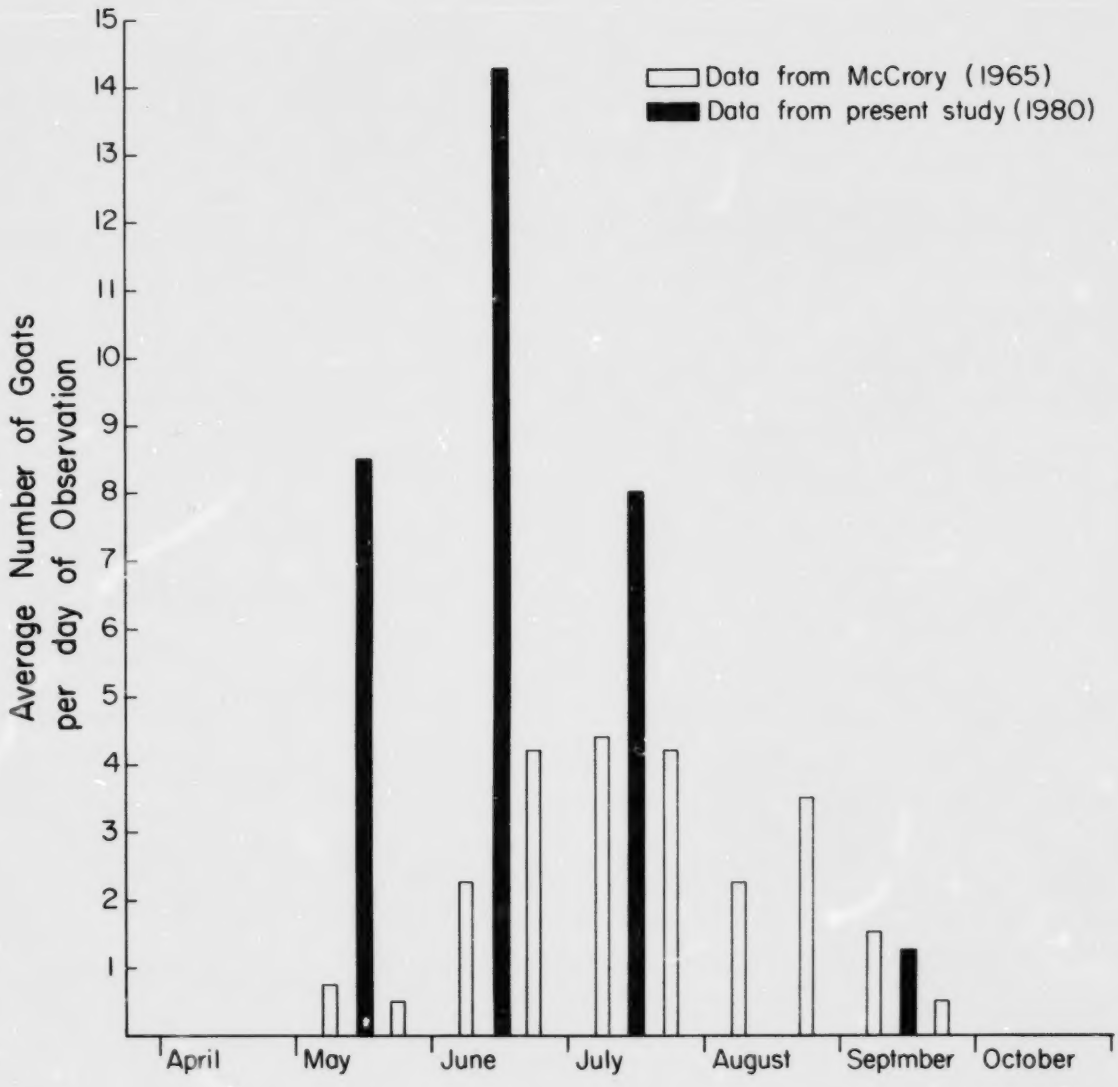
During the summer, goats visit mineral licks that are often several kilometers from feeding areas (Figure 7.1, 7.2). Most licks in Banff and Jasper that are used by goats are dry licks. It is thought that a deficiency of required body salts due to pregnancy, lactating and/or molting triggers movement to mineral licks (McCrory 1965).

The earliest recorded use of a lick by goats during this inventory was 26 April and the latest was 28 September. There are warden records of lick use from 14 April to 14 October and one exceptional record on 24 February 1969. Winter lick use is unusual since snow restricts goat travel and lick sites are generally frozen. Peak use of the Athabasca Falls mineral lick was during June in 1980, as was also the case during McCrory's (1965) earlier study (Figure 3.54). Jacobson and Loewan (1980) found that greatest use of a mineral lick on the west slopes of Lipalian Mountain near Lake Louise was from June until early August.

Goats were seen using the Mt. Kerkeslin licks as early as 10:00 a.m. to as late as 6:30 p.m. McCrory (1965) found that most sheep and goats arrived at the Shalebanks Lick in east-central Jasper National Park between 10:00 a.m. and 3:00 p.m. (MST). He related this to diurnal feeding activity. He believed that goats and sheep left for the lick after morning feeding periods.

MANAGEMENT CONSIDERATIONS

Figure 3.53. Seasonal use by mountain goats of the Athabasca Falls mineral lick.



Most goat range is far removed from direct human harassement or development. There are nonetheless a number of human activities that affect goats in Banff and Jasper.

Ski hill development and associated activities at Lake Louise have been shown to have direct impact on goat populations (Jacobson and Loewen 1980). In this area, goat habitat is occupied by lifts and ski runs. The actual population decline in the Lake Louise area is attributed to downhill and cross-country skiing, hiking and ski area development in this area. Other ski areas also have the potential to impact goats and their habitat, most notably at Marmot Mountain in Jasper.

Mountain ski touring is becoming increasingly popular. This form of backcountry travel enables skiers to reach areas that were previously out of the reach of cross-country skiers. This activity should be controlled in areas of known goat winter range, such as Parker's Ridge and the east slope of Lipalian Mountain.

Goats are particularly sensitive to harassment by aircraft (Ballard 1975). Goats, and ungulates in general, are most vulnerable to harassment during the late winter and early spring when remaining energy reserves are limited. Late winter storms can also severely stress ungulates. Aerial censuses in late winter, especially after heavy snowfalls, should be avoided.

Very little harassment of goats by human was noted at a roadside mineral lick below Mt. Kerkeslin in Jasper, although goats have been observed to flee from a more isolated high elevation lick in the Lake Louise area (Jacobson and Loewen 1980). It is possible that goats visiting the Kerkeslin mineral lick have become accustomed to human presence, although Horejsi (1976) claims that the mere presence of humans within a goat's home range may cause passive harassment which he defined as "a stimulus that causes a stress factor but does not cause flight".

Avalanche control along the Wilson Range and Parker's Ridge may affect goats wintering in these areas. At the Lake Louise ski area bands of goats have abandoned winter range because of avalanche control blasting (Jacobson and Loewen 1980). This may also occur on Bourgeau and Marmot Mountains.

BIGHORN SHEEP *Ovis canadensis canadensis* SHEE

STATUS AND DISTRIBUTION

In Canada, Bighorn sheep occur primarily in the Rocky Mountains south of latitude 55°N (Banfield 1973). They occur locally on ranges or spurs of the Rockies in both Alberta and British Columbia. The estimated population of Bighorn sheep in Alberta in 1974 was 7100 - 7900 (Wishart 1978).

The first mention of bighorn sheep in the vicinity of Banff also constitutes the first description of the species. On 30 November 1800 Duncan McGillivray and David Thompson encountered a herd of twenty near the present site of Exshaw, east of Banff. McGillivray, thinking they were deer, was surprised on closer inspection to find a herd of animals "that were utterly unknown to me" (Thorington 1947).

Subsequent travellers indicated that sheep ranged in the early 1800's over much the same areas where they occur today (Southesk 1875, Coues 1897, McEvoy 1900, Spry 1967) but were somewhat more abundant that now. The history of sheep in the Canadian Rocky Mountains has been examined in detail by Stelfox (1971).

Bighorn sheep distribution in Banff and Jasper corresponds closely to that mapped and described by Stelfox (1978). Sheep formerly wintered on Mount Kerkeslin and along Portal Creek in Jasper. These populations are now extirpated, having been eliminated by

Figure 3.54. Distribution of bighorn sheep observations in Banff, summer and winter.

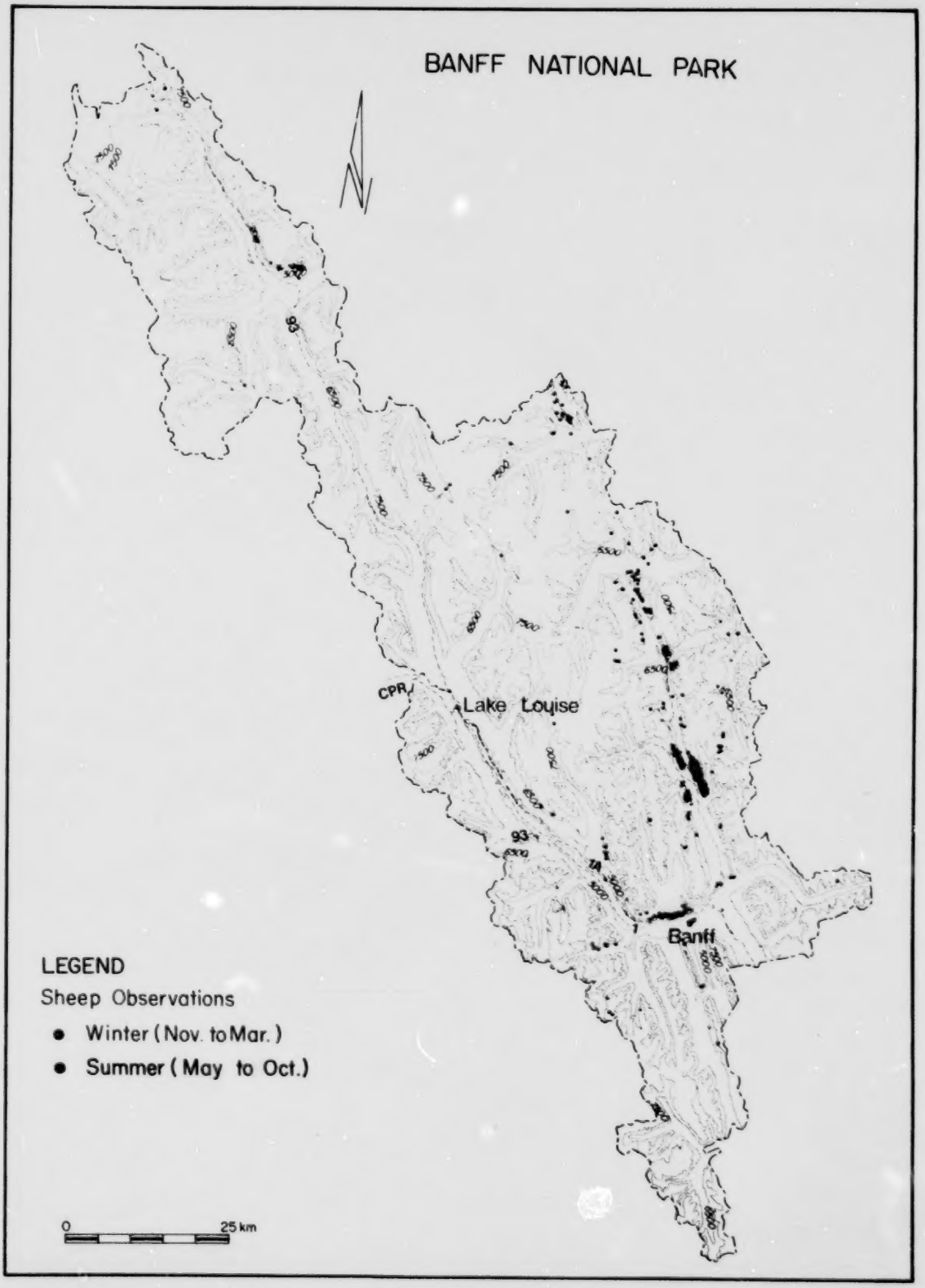
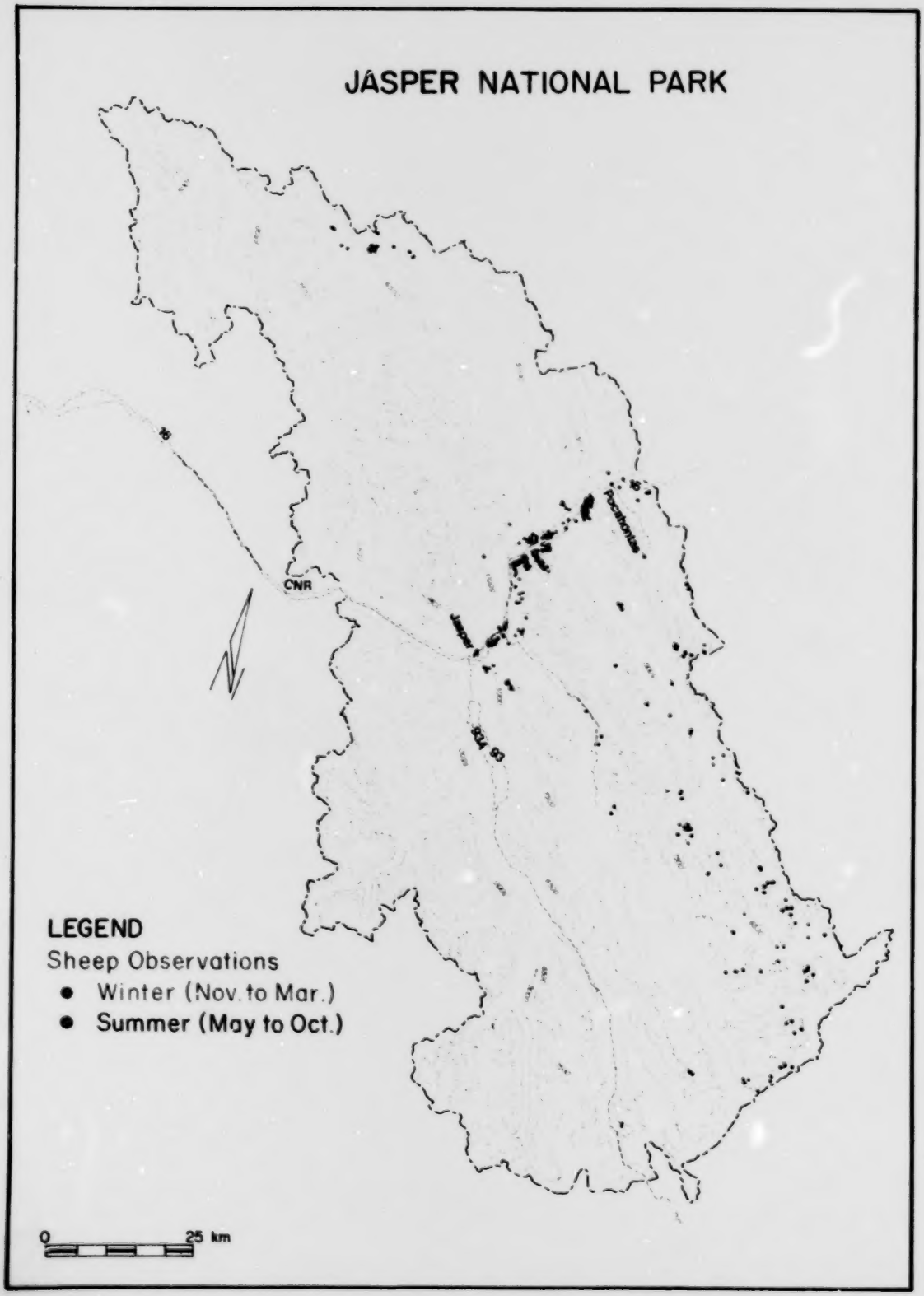


Figure 3.55. Distribution of bighorn sheep observations in Jasper, summer and winter.



severe winters and disease between 1947 and 1950 (Stelfox 1978; A. Burstrom, Jasper warden service, pers. comm.). These populations were on Main Range mountains, existing at the margins of climatic conditions tolerable to sheep. Other than small populations on Mount Bourgeau, Mount Wilcox and the base of the Victoria Cross Range, most Banff and Jasper sheep populations are in the drier Front Ranges and winter in areas of low snow accumulation (Figure 3.55, 3.56).

Sheep populations in Banff and Jasper have fluctuated markedly during the last 150 years, largely in response to variable winter severities and to the build-up of disease and parasites in populations (Stelfox 1978). Estimated populations of Banff and Jasper in 1972 were, respectively, 965 to 1310, and 1955 to 2270 for a total estimated population of 2920 to 3580 sheep. Based on maximum single-herd counts by watershed the minimum combined sheep population of Banff and Jasper between 1975 and 1980 was 1033 (Table 3.49). This method greatly underestimates sheep populations; actual sheep numbers at present are probably at least double this estimate. Adequate data to more accurately estimate sheep population sizes is not consistently available for all populations.

Rutting areas of sheep in Banff and Jasper (Figures 3.58, 3.59) are described in detail by Stelfox (1978). Stelfox also makes the point that a great many sheep which summer and rut in Banff and Jasper winter on ranges outside the park. Banff and Jasper provide refugia from heavy hunting pressure on adjoining provincial lands in addition to providing a significant proportion of the annual kill of rams which wander out of the parks.

HABITAT

During the summer, Bighorn sheep are widespread and are found in all 3 ecoregions (Figure 3.57). On ecosites in which sheep pellets were recorded, there were 9.49 pellet groups/ha in the montane ecoregion, 10.50 pellet groups/ha in the lower subalpine ecoregion, 29.15 pellet groups/ha in the upper subalpine ecoregion and 71.26 pellet groups/ha in the alpine ecoregion.

The most important summer habitats are alpine and upper subalpine herb meadows, particularly grasslands with hairy wildrye, alpine redtop, sedges, junegrass and other graminoids as well as dry tundra with mountain avens, *Kobresia* and snow willow. Other highly important habitats include heath meadows and dry low shrub communities on avalanche slopes (Tables 3.51, 3.52). Talus slopes are used for bedding and as escape terrain.

Moderately important habitats include moist open forests of subalpine fir, larch and Engelmann spruce with herbaceous or willow-dominated understories, open Douglas-fir and mixed coniferous forest, and upper subalpine shrub communities on avalance slopes and colluvial aprons.

Hudson et al. (1976) found that during the summer Bighorn sheep distribution is associated to a greater degree with forage protein content than terrain. Bighorn sheep remain almost exclusively on grasslands and rocky escarpments, not only during the summer but year-round, foraging on a variety of grasses, forbs and low shrubs (Stelfox 1978). During the summer Bighorn sheep are commonly found at high elevations (above 2100 m) on south and west slopes and along valley bottoms as snow fields recede, exposing succulent green vegetation.

Rams and ewes are spatially separated on their summer ranges both geographically (Stelfox 1978) and with regard to elevation (Shank 1979). On the average, Shank found a 60 m vertical difference between the two, with the rams occupying the higher elevations.

In the winter, Bighorn sheep occur in all 3 ecoregions, however they range over a smaller area. There were 95.96 winter pellet groups/ha in the montane ecoregion, 41.64 pellet groups/ha in the lower subalpine ecoregion, 73.24 pellet groups/ha in the upper

Table 3.49. Largest recorded sheep herds during winters from 1975-80.

JASPER		*BANFF*	
Athabasca (Low)	93	Bow (Low)	31
Athabasca (Mid)	16	Bow (Mid)	36
Blue	24	Cascade (Low)	44
Brazeau (North)	19	Cascade (Mid)	51
Brazeau (Low)	49	Clearwater	29
Cairn	42	N. Saskatchewan (Low)	38
Townsite	18	Panther	40
Fiddle	63	Red Deer (Low)	26
Isaac	51	Spray (Low)	30
Medicine-tent	29	Healy	42
Moosehorn	18		
Rock	39		
Rocky (Low)	45		
Snake Indian (Low)	40		
Snake Indian (Mid)	47		
Southesk	51		
Sunwapta	22		

Total: 1033

subalpine ecoregion and 120.00 pellet groups/ha in the alpine ecoregion, on ecosites where sheep pellets were recorded.

Mesic to subxeric grasslands are an essential component of Bighorn sheep winter habitat (Table 3.51, 3.53). These include montane grasslands characterized by *Agropyron dasystachym* or *Koeleria cristata* to grassland tundra charactrized by *Dryas octopetala* and *Kobresia myosiroides*. Mesic to subxeric grasslands comprise 41% of the important vegetation types, subxeric forests comprise 22%, while subxeric low shrub meadows and willow thickets comprise 18.8%.

Some of the climatic factors affecting Bighorn sheep during the winter include snow depth, barometric pressure, wind velocity and snow resistance (Stelfox 1978). Ungulate mobility is noticeably impaired when snow depths become two thirds as great as the animal's chest height (Kelsall and Telfer 1971). Chest heights for lambs, yearlings, ewes and rams are 44.0, 47.7, 48.6 and 53.9 cm. respectively and it is felt that sheep avoid snow depths of greater than 30 cm. (Stelfox 1978). This inability to travel and forage in deep snow limits Bighorn sheep in winter to steep grasslands that are exposed to wind or receive low snowfall or, in the case of some montane ranges, receive frequent thaws (Table 3.51). Windblown meadows and alpine tundra are also used during the winter. Hudson et al. (1976) found Bighorn sheep distributed locally on steep relatively snow-free slopes and rugged terrain of southwest aspect. Shank (1979) found that mature rams used meadow terrain, snow covered areas and higher elevations to a greater extent then other Bighorn sheep. Rams are less constrained by snow than the smaller and physically weaker ewes and juveniles. Morgantini and Hudson (1981) agree that there is a difference in habitat selection and spatial distribution between the sexes, however they disagree with the hypothesis regarding reasons for this separation.

Figure 3.56. Bighorn sheep rutting ranges, Banff National Park.

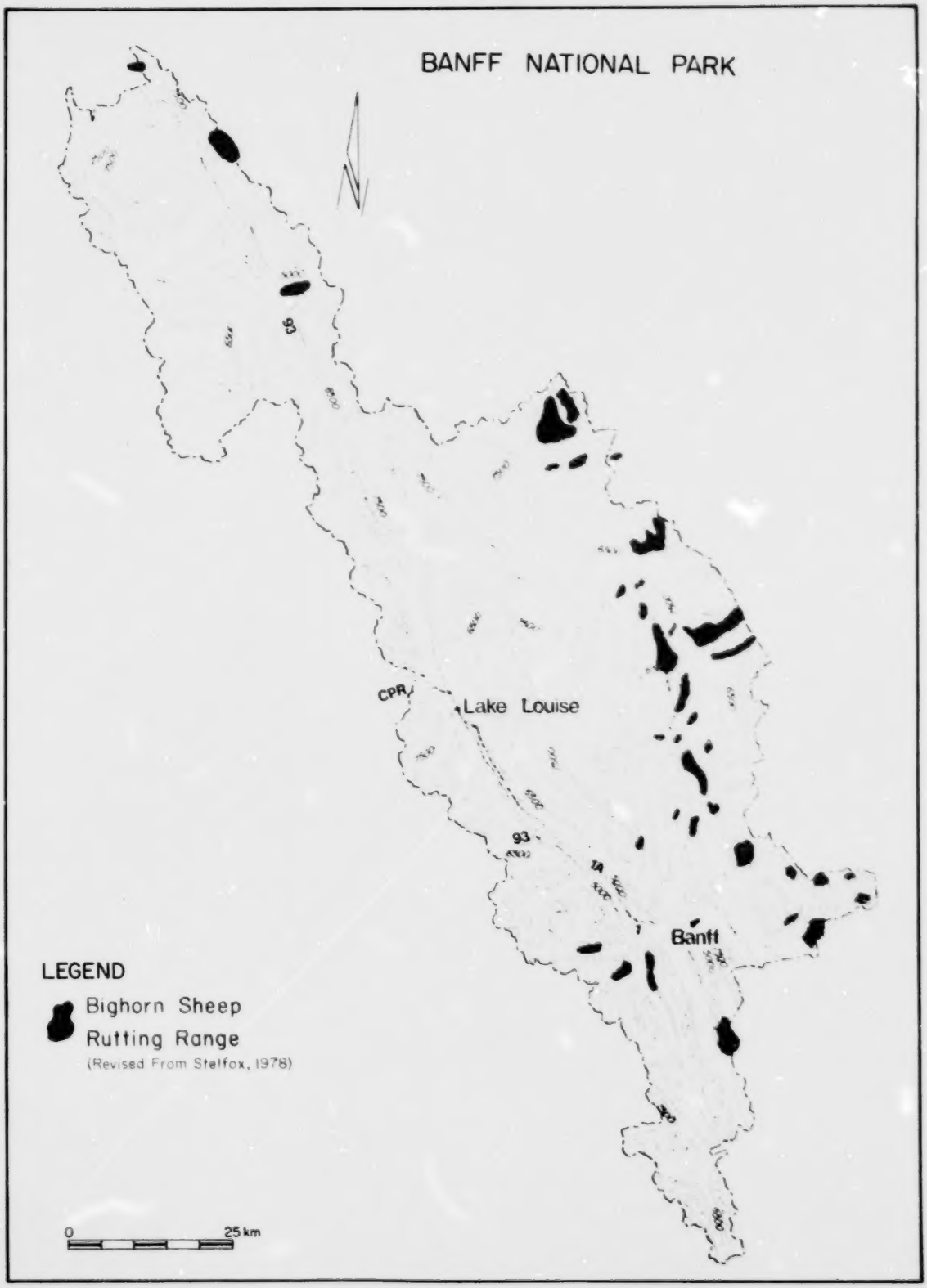


Figure 3.57. Bighorn sheep rutting ranges, Jasper National Park.

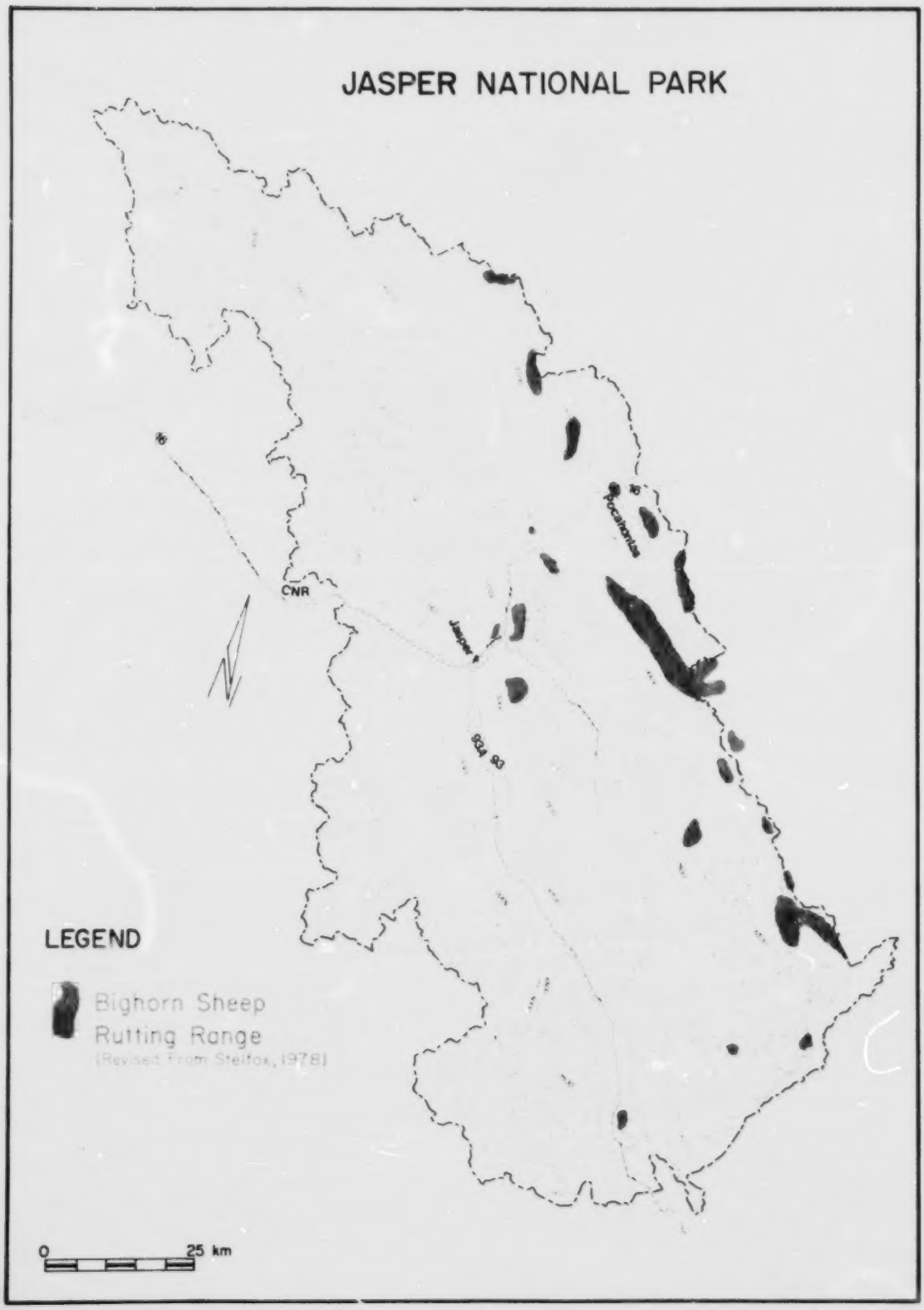


Figure 3.58. Habitat use by bighorn sheep, based on pellet group densities.

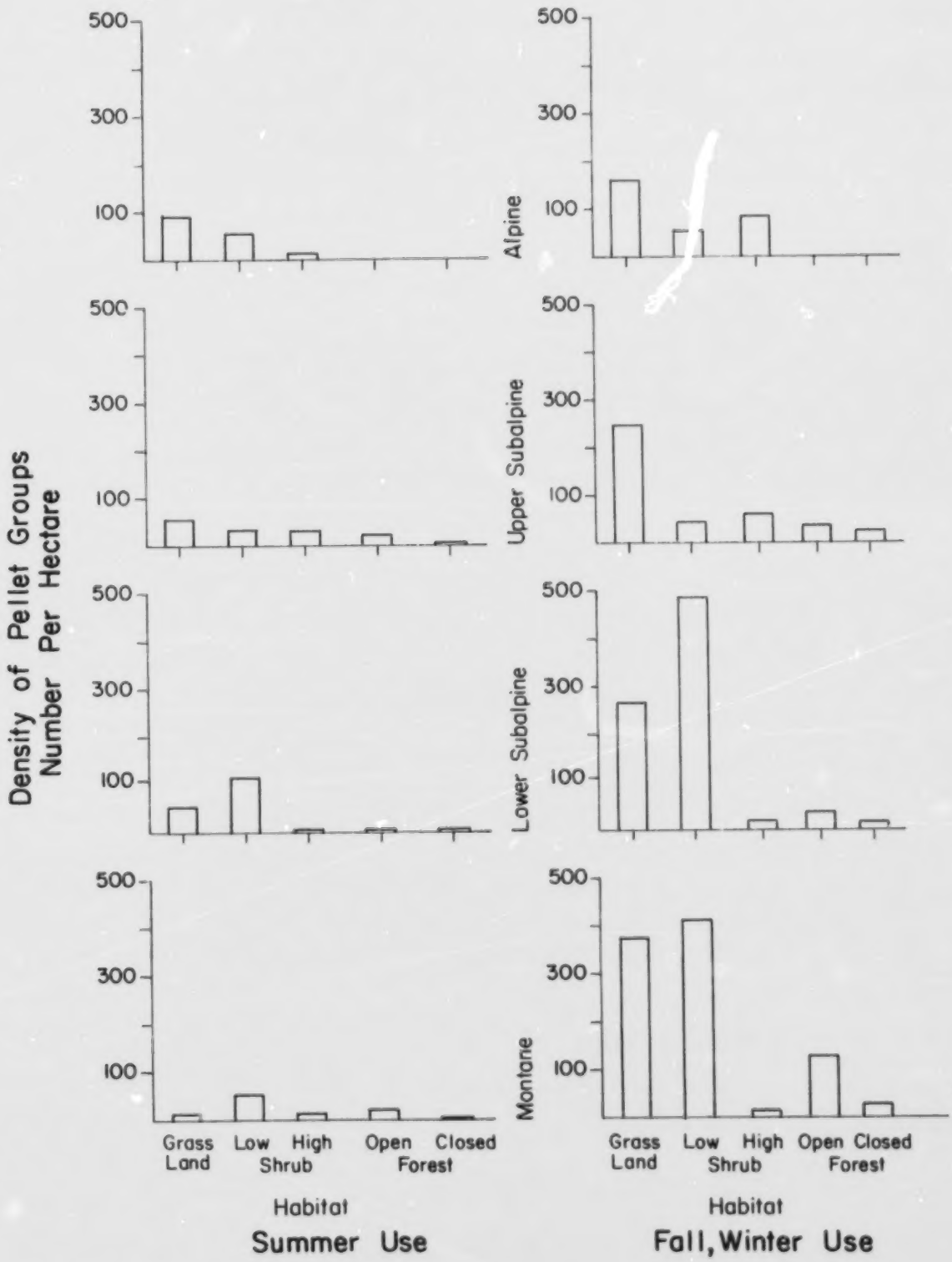


Table 3.50. Highly important spring and early summer ecosites for bighorn sheep.

Ecosite	Pellet groups/ha	Ecoregion	Parent material	Vegetation
RD1	211.9	alpine	glacial till	dryas tundra; heath
HE1	101.7	alpine	weathered rock	dryas tundra
KA1	101.0	alpine	alluvium	willow scrub; dryas
WF4	97.1	upper subalpine	colluvium	spruce forest
WF7	94.7	upper subalpine	colluvium	grassland
PL4	92.4	upper subalpine	glacial till	open spruce-fir forest
SB1	81.3	lower subalpine	colluvium	avalanche shrubbery
TR2	78.2	upper subalpine	glacial till	herb meadow
BS1	77.8	alpine	colluvium	dryas tundra
TA2	72.7	montane	silt (eolian)	grassland
SB5	65.5	lower subalpine	colluvium	grassland
GT2	60.9	lower subalpine	glacial till	lodgepole pine forest and grassland
TR1	47.9	upper subalpine	glacial till	willow scrub
NY3	47.0	montane	ice-contact drift	Douglas fir forest
SX3	45.7	upper subalpine	glacial till	willow shrubbery
WF2	45.0	upper subalpine	colluvium	avalanche shrubbery

The winter distribution of Bighorn sheep will vary from year to year depending upon snow conditions. In winters of low snow accumulation their potential winter range is larger, and in winters of exceptionally heavy snowfall winter ranges may become confined to the point that they cannot sustain the population using them.

Stelfox (1974) found a positive correlation between barometric pressure and Bighorn sheep numbers. When the barometric pressure dropped, Bighorn sheep tended to move to grassland areas sheltered from the oncoming storm, or to an ecotone between forest and grassland where they could wait out the storm. Conversely, with an increase in barometric pressure sheep return to the more exposed grasslands.

In the spring, valley bottoms and low elevation south-facing slopes are important to Bighorn sheep, particularly pregnant females, as these are the first areas to green up and provide the high protein forage necessary during late pregnancy and early lactation (Stelfox 1978). Without this high protein diet reproductive rates decrease and juvenile mortality increases (Herbert 1973). Spring green-up areas are frequently the most critical ungulate ranges since they determine how soon and to what extent ungulates will recover from the ravages of winter.

During warm weather in spring, sheep make heavy use of forest cover (Morgantini 1979). In April and May, Bighorn sheep may still have the bulk of their winter coats and

Table 3.51. Highly important late summer, autumn and winter ecosites for bighorn sheep, based on pellet count data.

Ecosite	Pellet groups/ha	Ecoregion	Parent material	Vegetation
TA2	712.7	montane	silt (eolian)	grassland
NY1	560.0	montane	glacial till	Douglas-fir forest
SB5	534.6	lower subalpine	colluvium	grassland
NY3	504.4	montane	ice-contact drift	Douglas-fir forest
WF7	417.5	upper subalpine	colluvium	grassland
TA3	282.9	montane	silt (eolian)	spruce forest
RD1	270.0	alpine	glacial till	dryas tundra; heath
GT2	260.8	lower subalpine	glacial till	lodgepole pine forest and grassland
BS1	244.3	alpine	colluvium	dryas tundra
SB1	225.0	lower subalpine	colluvium	avalanche shrubbery
HD4	202.9	montane	alluvium	grassland with scattered pines
SB4	190.0	lower subalpine	colluvium	open coniferous forest
WF3	178.5	upper subalpine	colluvium	open coniferous forest
TR2	176.4	upper subalpine	glacial till	herb meadow

thus are susceptible to heat stress.

LIFE HISTORY

Food habits

Both Stelfox (1974) in Banff and Jasper, and Herbert (1973) in B.C., determined that forbs and shrubs are nearly as important as grasses to sheep as sources of year-round nutrition. Stelfox found that grass was most important in winter but that even during summer, when it received lowest use, it was more important than forbs and shrubs. Artificially-seeded grasslands are of less value to sheep than natural grasslands, since the variety of plants present in natural grassland results in a much longer period when various species are at the most nutritious "greening-up" phase (D. Jacques, University of Calgary, pers. comm.).

Seasonal food habits of sheep vary considerably since sheep feed more or less selectively on whatever species provide the highest quality forage at any one time (Geist 1971).

Rut

During September and early October rams move from summer ranges onto pre-rut concentration areas, at the same time as ewes and young begin to assemble on winter

Table 3.52. Highly important spring and early summer vegetation types for bighorn sheep, based on pellet count data.

Description	*Vegetation type*
Hairy wildrye–alpine redtop–sedge avalanche meadow	H5
Sedge–pussytoes tundra	H2
Mountain avens–golden sedge tundra	H4
Hairy wildrye–junegrass grassland slope	H14
Shrubby cinquefoil/fleabane–wild blue flax dry slope	L1
Moutain marigold–globeflower wet meadow	H9
White dryas–sedge meadow	H15
Mountain avens–berry–golden sedge tundra	H17
Mountain avens–snow willow–moss campion tundra	H1
Heather–mountain avens–snow willow heath meadow	L4
Heather–everlasting heath meadow	L5
Juniper–willow talus slope	L2
Arctic willow–clinquefoil shrub meadow	L7
Dwarf birch–willow–shrubby cinquefoil shrub meadow	S10
Douglas–fir/juniper–blue bunch wheatgrass open forest	O5
Subalpine larch/heather open forest	O13
Engelmann spruce–subalpine fir/valerian–fleabane open forest	O9

ranges (Geist 1971, section 4). In late October rams begin to join the ewes on the ewe winter ranges and rutting begins in November. The earliest record of rutting behaviour in Banff and Jasper is 27 October in the Panther River drainage and the earliest estrous ewe observed was on 9 November 1978 in the lower Athabasca River valley. Most ewes begin to come into estrous in late November (Geist 1971). Most rutting activity occurs during the last three weeks of November and the first week of December, with latest recorded rutting behaviour being 28 December at Vermilion Lakes.

Lambing

On some winter ranges rams and ewes remain together but use different parts of the same slopes while on other winter ranges the rams separate from the ewes soon after the rut (Geist 1971). In either case, any loose association ends in late March and April when sheep begin to disperse onto green-up areas. Pregnant ewes withdraw into high, rocky terrain about two weeks before parturition. The earliest recorded lamb during this inventory in Jasper was on 4 June 1976 in the lower Athabasca River watershed but this lamb was at a lick and was several days old. The earliest recorded lamb in Banff was on 8 May 1979 in the lower Bow River valley. Smith (1954) felt that the last week of May was the peak lambing time in the southern Canadian Rockies, while Stelfox considered 1 June to be the peak.

Lick use

Mineral licks are evidently of considerable importance to sheep as they will frequently travel severalmis from their summer ranges to visit mineral licks in forested valley-bottoms. McCrory (1967) described use of licks by sheep and goat in Jasper and suggested that ewes, subsequent to parturition, needed licks to replenish body minerals. Ram groups are observed at licks in May, while ewe groups visit licks sporadically throughout the summer. Stelfox (1978) describes the locations of several licks used by sheep in Banff and Jasper, and a number of licks have been identified by park wardens and wildlife inventory staff (Figure 3.58, 3.59).

Table 3.53. Highly important late summer, autumn and winter vegetation types for bighorn sheep, based on pellet count data.

Description	*Vegetation type*
Junegrass-everlasting-wild blue flax grassland	H6
Wheatgrass-pasture sage grassland slopes	H7
Juniper-wheatgrass-blue flax-pasture sage grassland	H19
Hairy wildrye-Junegrass grassland	H14
Hairy wildrye-alpine redtop-sedge grassland	H5
Mountain avens-golden sedge tundra	H4
Mountain avens-golden sedge tundra	H17
Mountain avens-snow willow-moss campion tundra	H1
Sedge-pussytoes tundra	H2
Juniper-willow talus slope	L2
Willow/hairy wildrye shrub meadow	S12
Dwarf birch-willow/golden sedge-fescue shrub meadow	S9
Douglas fir-hairy wildrye closed forest	C1
Limber pine/juniper/rough fescue open forest	O2
Aspen/prickly rose/berry open forest	O1
Lodgepole pine-(Douglas-fir)-spruce-whitebark pine open forest	O4
Lodgepole pine/juniper/berry closed forest	C3
Mountain marigold-blobeflower wet meadow	H9

Productivity

Productivity varies in Bighorn sheep both from one year to the next and between populations. Nutrition, winter stress and disturbance all influence the number of young born to a population each year (Geist 1971). The pronounced population fluctuations that have been reported in Banff and Jasper Bighorn sheep (Stelfox 1971) provide further evidence of variable productivity. Twinning is extremely rare in sheep (Geist 1971) and has not been observed in Banff and Jasper. Productivity in sheep herds censused in the Cascade valley of Banff was about 22 lambs per 100 ewes, and along the lower Athabasca River valley in Jasper it was about 38 lambs per 100 ewes (section 4). These levels are lower than recorded by Stelfox (1976b) and higher than recorded by Geist (1971), but fall within the average range for sheep in Banff and Jasper (Table 3.54).

Productivity of sheep in Banff and Jasper averages about 32 lambs/100 ewes, and Jasper populations are slightly more productive than Banff ones (Table 3.54).

Mortality

Sheep populations in the Rocky Mountains of Alberta are subject to periodic die-offs related to a pneumonia/lungworm disease complex which is aggravated by over-crowded conditions on depleted winter ranges during severe winters (Stelfox 1971). Disease and parasitism are most widespread in populations subjected to overcrowding whether by overpopulation or by concentration at unnatural salt sources (Stelfox 1976a).

The major consistent sources of sheep mortality in Banff and Jasper are collisions with trains and motor vehicles (Table 3.55). Unnatural mortality of this nature has been the major factor in an on-going decline of 5 sheep populations in Jasper and 1 in Banff and could lead to further local extinctions (section 7, Athabasca watershed account). Predation is another source of mortality of Bighorn sheep, with wolves, cougars and coyotes being of equal importance (Table 3.56). Poaching and legal hunting outside the park boundaries removes a significant number of the dominant rams, with possible

Table 3.54. Bighorn sheep productivity rates recorded in Banff and Jasper.

Dates	Location	YOY/ 100 F	Reference
Summer, autumn 1964	Banff (Cascade valley)	16–18	Geist 1971
November 1979	Banff (Cascade fire road)	22–23	sec. 4.2.3; this report
Nov. to Jan. 1966 to 1971	Banff (whole park)	52	Stelfox 1976b
Nov. to Jan. 1975 to 1981	Banff (whole park)	34	Warden wildlife cards
Nov. to Jan. 1966 to 1971	Jasper (whole park)	45	Stelfox 1976b
Nov. to Jan. 1975 to 1981	Jasper (whole park)	35	Warden wildlife cards
December 1978	Jasper (lower Athabasca valley)	38	sec. 4.2.4; this report

disruptive effects on social structure in certain populations (Geist 1971).

Avalanches and accidental falls doubtless take an undeterminable toll of sheep each year, particularly in winter. Following a freezing rain in December 1980, 16 sheep slid to their death at the south end of Talbot Lake in one of the few documented cases of an accident of this nature.

MANAGEMENT HISTORY

Bighorn sheep have traditionally been regarded as one of the more desirable members of Banff's and Jasper's fauna. In the 1950's concern over possible displacement of sheep by elk on Banff's Palliser Range led to a brief study by Tanner (1950). He recommended that both elk and wolves be killed in the Cascade valley to protect sheep. Slaughters of elk were, in fact conducted in Banff and Jasper in order to reduce grazing pressure on winter ranges, and elk were shot throughout the 1950's, but no controlled slaughters of sheep were ever conducted.

In 1971, however, twenty sheep were captured in Jasper and shipped to Idaho to re-stock depleted ranges. Three sheep were also sent to a game farm near Kamloops B.C. and others were transplanted to New Mexico. These operations apparently took place on an *ad hoc* basis as no others are documented and no policy developed with regard to transplants of park animals.

A massive die-off of sheep in southeastern B.C. in the late 1960's triggered concern in Banff and Jasper that a similar die-off might occur there. John Stelfox of the Canadian Wildlife Service was requested to investigate the status of sheep populations and range throughout the mountain parks. His research (Stelfox 1971 1975 1978) constituted one of the first detailed ecological investigations of a single species initiated by Parks Canada and, with work by V. Geist of the University of Calgary (Geist 1971), provided a wealth of detailed information for sheep management in subsequent years.

MANAGEMENT CONSIDERATIONS

Sheep are of particular management concern for a number of reasons. In the Canadian national parks Bighorn sheep occur only in Waterton Lakes, Kootenay, Banff and

Table 3.55. Causes of sheep mortality in Banff and Jasper National Parks, from park wildlife cards, 1945 to 1980).

Cause	Banff	Jasper	Total
Railroad kills	0	236	236
Road kills	70	167	237
Predators	12	39	51
Disease/ Starvation[0]	3	17	20
Injury[0]	6	5	11
Avalanches	7	6	13
Miscellaneous[0] [0]	3	9	12
Unknown	26	56	82
Totals:	127	535	662

[0] Includes animals destroyed by wardens.
[0] [0] Drowning and poaching.

Jasper. They are uniquely associated with relatively dry mountain and periglacial environments and are of particular interest to visitors to the Rocky Mountains. They occur in distinct populations with complex social interactions and seasonal movement patterns and inherited knowledge of often-isolated ranges (Geist 1971) and hence are vulnerable to disturbance. Once a population has been extirpated or consistently disturbed for a long enough period, chances are that the range it occupied will not be re-occupied, since sheep are not usually colonizers.

Two populations of sheep in Banff and Jasper have been extirpated in historical times, both by natural causes. The Graveyard sheep population which winters adjacent to Jasper townsite is in imminent danger of extirpation because of excessive mortality from trains, and at least four other Jasper sheep populations are also declining because of unnatural mortality on the CNR railroad and highway 16 (Van Tighem 1981). Flygare (1976 and 1979) documented the severity of the roadkill problem on the Norquay winter range in Banff. Unlike other ungulates such as elk, deer and moose which are known to be capable of colonizing new ranges and dispersing through unsuitable habitat into suitable areas, sheep are not likely to re-establish themselves once a population has been eliminated. Consequently it is essential that unnatural mortality of sheep along railroad and highways in Banff and Jasper be stopped, particularly in populations which have shown declines in the last ten years. These herds include the Sawback/Norquay population which has declined from more than 375 in 1919 (Mair 1952) to about 70 in 1980 (Gail Harrison, Parks Canada, pers. comm.), the Graveyard population which has declined from more than 200 in the late 1950's to less than 30 in 1980 (Van Tighem 1980), and all other sheep populations wintering in the lower Athabasca River valley.

Mortality would be significantly reduced if railroads are effectively fenced. Salting of highways adjacent to sheep winter range should be avoided and existing regulations prohibiting the feeding of sheep strictly enforced in order to reduce sheep mortality on highways. Reduced speed limits have not been found to be effective in preventing sheep deaths on the trans-Canada highway (Flygare 1979) and only fencing of the highway at kill sites can be expected to eliminate this source of mortality (section 1).

Table 3.56. Sources of Bighorn sheep predation in Banff and Jasper National Parks (from park wildlife cards, 1945 to 1976).

		Sheep killed (by age/sex class)					
Predator	**Park**	**M**	**F**	**YOY**	**YLY**	**UNK**	**Total:**
Wolf	B	0	1	0	0	0	1
	J	0	8	0	3	1	12
Coyote	B	0	0	0	0	0	0
	J	4	1	0	1	0	6
Dog	B	0	0	0	0	0	0
	J	0	0	1	0	0	1
Grizzly	B	1	0	0	0	0	1
	J	2	0	0	0	0	2
Cougar	B	1	3	1	0	2	7
	J	1	4	0	1	2	8
Wolverine	B	0	0	0	0	0	0
	J	0	0	0	0	1	1
Unknown	B	1	0	0	0	0	1
	J	1	0	0	0	1	2
Totals		11	17	2	5	7	42

B=Banff
J=Jasper

The use of salt blocks to attract sheep away from kill sites or areas of heavy human use is effective but has been shown to cause an increase in contageous ecthyma and, possibly, other diseases and parasites in sheep (Stelfox 1976a). Consequently, it is not a viable alternative to more direct forms of reducing highway and railroad mortality.

Habitat loss has been implicated in the decline of some sheep populations in Banff and Jasper (Stelfox 1976b). Forest succession on slopes bared by fires in the early part of the 20th century has been well-documented, particularly in the Bow valley (section 1.). Fire control policy is such that there is little likelihood of this range loss being reversed unless controlled burns are allowed. Habitat loss to highway and railroad expansion can be to some extent mitigated if slope cuts are thoroughly reclaimed and seeded to legumes and grasses, however the benefits of such reclamation are lost if sheep are killed by trains and vehicles more often as a result of being attracted to the re-seeded cuts.

Since a significant number of Banff and Jasper Bighorn sheep range outside the park, particularly in winter, disturbance of winter ranges for mineral exploration and extraction, and increased access to park boundaries by provincial resource roads may have far-reaching detrimental effects on park sheep populations. Active consultation and cooperation with provincial fish and wildlife and land-use agencies is required to ensure that these effects do not occur.

Part B

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4. WILDLIFE SURVEYS

This section describes the results of surveys to determine the timing, nature and magnitude of bird migration and seasonal movements of ungulates. The methods are described above (section 2).

4.1. BIRD MIGRATION SURVEYS

Since different groups of birds were more adequately sampled on some survey routes than others, it was necessary to analyse waterfowl, shorebirds and other wetland-associated birds separately from woodpeckers, warblers and other families more commonly associated with terrestial habitats. Some routes were censused on two or three consecutive years while others were censused only once; this limited the number of species and locations for which yearly changes in migration patterns could be determined. The following sections treat wetland - associated species independently from more terrestrial ones, using data from surveys which best documented the species in question.

4.1.1. DATA ANALYSIS

Waterfowl and Shorebirds

Two spring and one autumn survey from Banff, and three spring and two autumn surveys from Jasper, were used to determine the relative abundance of selected species of waterfowl and shorebirds during migration. Only species common and detectable enough to yield meaningful results were considered. Data from the following routes were used in this analysis:

		Route	Dates	N	stops/ route
Banff	Spring 1977	Vermilion-Minnewanka	23 Mar - 30 May	18	16
	Spring 1978	Vermilion-Minnewanka	18 Mar - 23 May	23	16
	Autumn 1977	Vermilion-Minnewanka	3 Aug - 25 Oct	18	16
Jasper	Spring 1977	Talbot	17 March - 28 May	11	29
	Spring 1978	Talbot	11 Apr - 31 May	8	29
	Spring 1979	Talbot	22 Mar - 27 May	11	29
	Autumn 1977	Talbot	6 Aug - 29 Oct	10	29
	Autumn 1978	Talbot	17 Aug - 1 Dec	24	29

Passerines and terrestrial species

Three spring surveys from each of Banff and Jasper, and two autumn surveys from Banff and three from Jasper, were used to determine the relative abundance of selected species during the two migration seasons.

Only species adequately sampled by these surveys were considered. Banff and Jasper were about equally represented in sampling effort in both the spring and autumn. Surveys used for this analysis are listed below:

		Route	Dates	N	stops/ route
Banff	Spring 1977	1A highway	27 Mar - 30 May	12	50
	Spring 1977	Bow Summit	18 Apr - 31 May	11	50
	Spring 1977	Vermilion Lakes	23 Mar - 30 May	14	16
	Autumn 1977	Canadian Wildlife Service lab- 5 mi bridge	2 Aug - 28 Sep	7	8.5km
	Autumn 1977	Vermilion Lakes	3 Aug - 25 Oct	18	16
Jasper	Spring 1977	Athabasca Falls	17 Mar - 26 May	9	50
	Spring 1977	Maligne valley	15 Mar - 29 May	10	50
	Spring 1977	Talbot Lake	17 Mar - 28 May	10	29
	Autumn 1977	Ft Point - Pyramid L	7 Aug - 26 Oct	8	4 km
	Autumn 1977	Five Lakes	20 Aug - 16 Oct	8	10 km
	Autumn 1977	Talbot Lake	6 Aug - 29 Oct	10	29

4.1.2. SPRING MIGRATION

Loons, grebes and waterfowl

During spring censuses of the Talbot and Vermilion-Minnewanka survey routes, 1 species of loon, 5 species of grebe and 25 species of waterfowl were recorded. Of these 31 species, 18 are migrants from or through the parks and the remainder, although they breed in the parks, are commonest during migration. Species recorded in Banff but not in Jasper were Eared and Pied-Billed Grebe, Snow Goose and Red-breasted Merganser. Species recorded only in Jasper were Oldsquaw and Harlequin Duck; the latter species, although as common in Banff as in Jasper, does not occur in the areas sampled by the Vermilion-Minnewanka survey.

Of the 31 species counted on spring surveys only one, the mallard, is a very common migrant and none are abundant by the New York State standards of abundance. Nine species are common by these standards, which are designed to be applicable throughout North America. The paucity of very common to abundant species indicates that Banff and Jasper are not on a major waterfowl flyway.

Three species - Mallard, Barrow's Goldeneye and Canada Goose - together comprised more than 50% of the migrants recorded in Banff and Jasper. More species of loons, grebes and waterfowl were recorded on spring surveys (31) than autumn surveys (28). Species which occurred in spring but not autumn are:

Oldsquaw
Harlequin Duck
Eared Grebe
Snow Goose

Figure 4.1. Counts of waterfowl on spring migration surveys in Banff and Jasper.

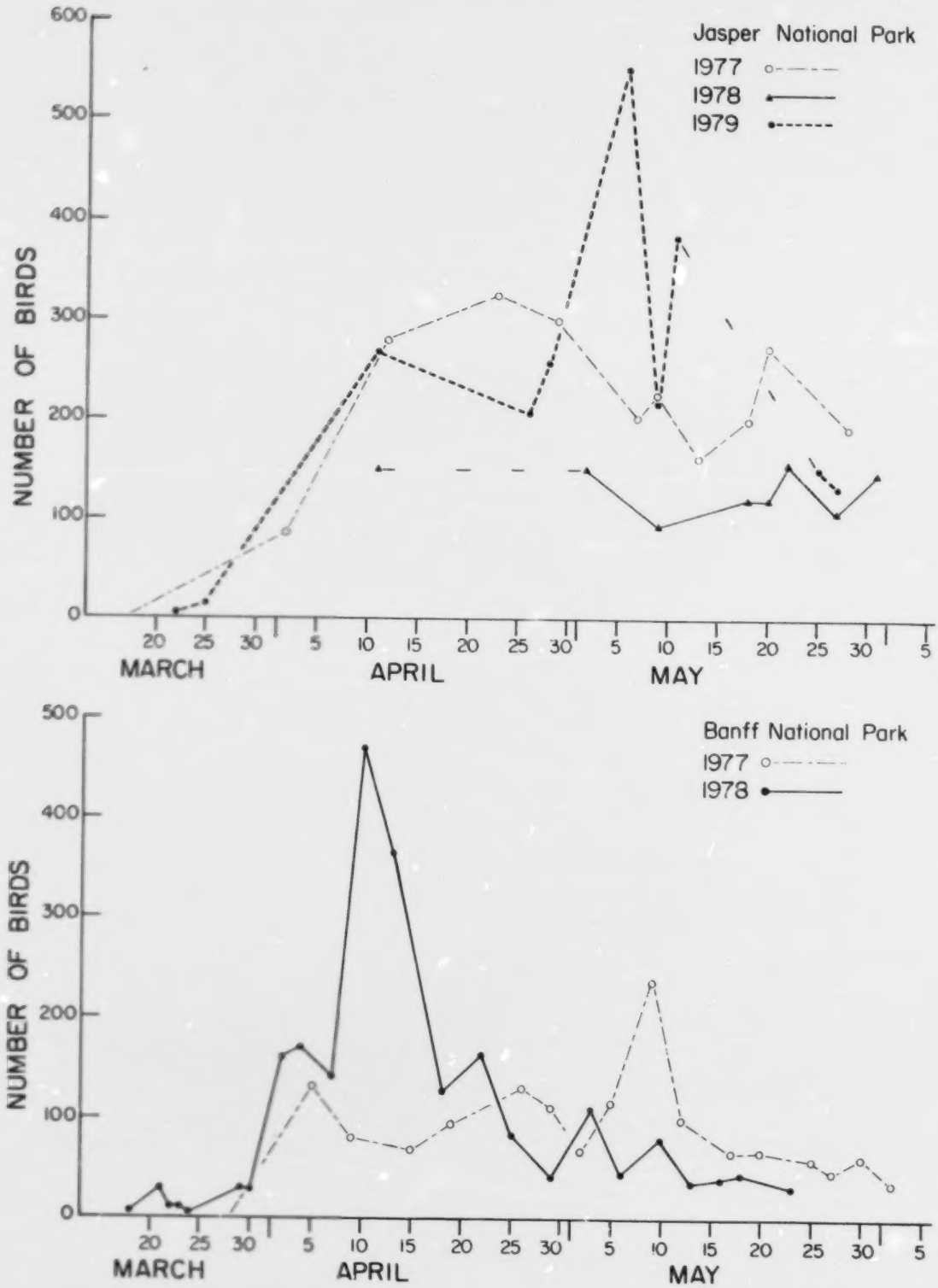


Figure 4.2. Numbers of species recorded on spring migration surveys in Banff and Jasper.

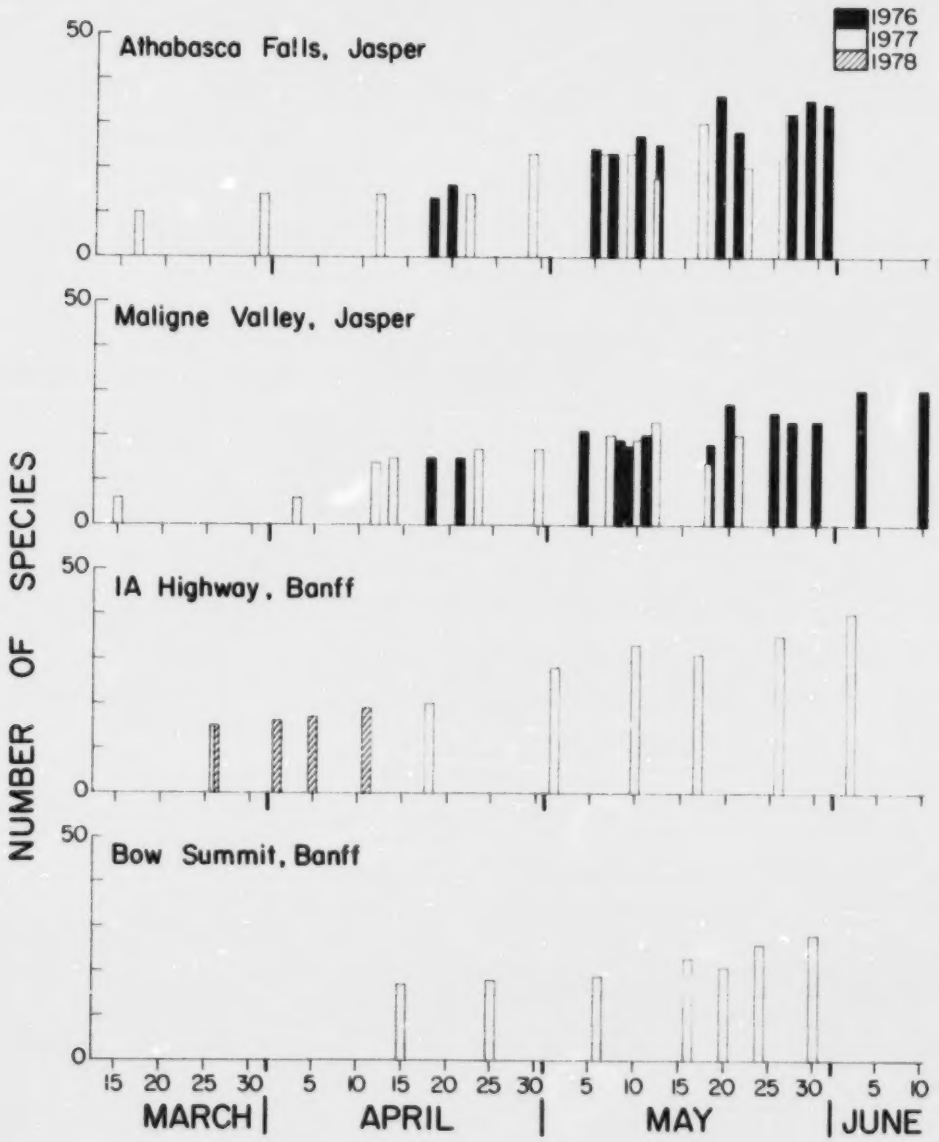
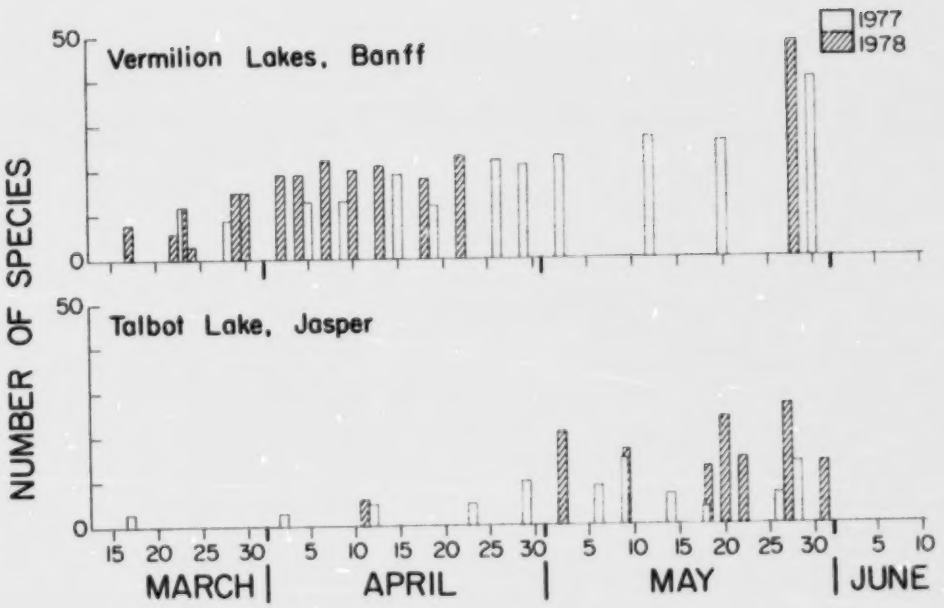


Figure 4.3. Numbers of species recorded on spring bird migration surveys in Banff and Jasper.



Spring migration begins in late March with the arrival of the first Mallards to augment the small numbers that winter in the parks (rarely more than 5 in Jasper but up to 200 in Banff). Other early migrants include Canada goose, Pintail, American Wigeon and Common Goldeneye (Figures 4.4, 4.5, 4.6, 4.7, 4.8). These species attain peak numbers by the second week of April and decline steadily thereafter until by early May most of the resident ducks and geese are incubating eggs.

Green-winged teal, Lesser Scaup, Barrow's Goldeneye, Red-necked Grebe and American Coot (Figures 4.9, 4.10, 4.11, 4.12, 4.13) are among the later spring migrants, peaking in late April and in May. Overall, the highest recorded counts of waterfowl were on 10 April 1978 in Banff and on 6 and 11 May 1979 in Jasper (Figure 4.1). The high Banff count was 67% mallards while the high Jasper counts were comprised primarily of unidentified ducks (21%), lesser scaup (14%) and Barrow's Goldeneye (15%) on 6 May, and of Western Grebe (27%) and Bufflehead (19%) on 11 May.

Comparison of spring migration between Banff and Jasper

In general, spring waterfowl migration peaks in Banff in mid-April and then decreases; in Jasper it continues to increase to a peak in early May. Diving ducks generally comprise a greater proportion of the migrants in Jasper (36.5%) than in Banff (25.8%) while dabbling ducks are proportionately more important in Banff (55.2%) than in Jasper (39.9%) (Table 4.1).

Although the habitats sampled by migration surveys in these two parks are generally similar, the lakes and wetlands in Jasper's lower Athabasca River valley are more numerous than in Banff and are in a more accessible position relative to the large lakes of the boreal region than are those in the Bow valley of Banff. One species of diving duck, the oldsquaw, was recorded regularly in Jasper but did not occur in Banff. This is in keeping with the observation by Salt and Salt (1976) that the oldsquaw "... is a regular spring migrant... north of the Athabasca River."

The greater relative abundance of Common Loon, Canada Goose and, possibly, Ruddy Duck in Jasper than in Banff (Table 4.1) probably reflects the greater extent of suitable habitat in the lower Athabasca River valley than in the Bow valley, or may reflect somewhat different migration routes for these species compared to others.

With the exceptions of Canada Goose and some of the uncommon species, most waterfowl exhibit at least one pronounced peak in numbers, followed by a sustained decline to less than half the peak, indicating that the Bow and lower Athabasca River valleys are used as spring staging areas by waterfowl passing through the park or dispersing into the park from more major migration routes to the east and west.

Latitude, elevation and yearly variations in migration

Waterfowl migration in Banff and Jasper varies from year to year and between parks. While mallards tended to arrive and peak in Banff and Jasper at about the same time (mid April) each year, Green-winged Teal peaked 10 days earlier in Jasper than in Banff in 1977 and American Wigeon peaked about 10 days later than in Banff. In 1977 Barrow's Goldeneyes peaked in Jasper a week later than in Banff, and in 1978 they peaked 4 weeks later.

In general, most species of waterfowl peak at about the same time in Jasper as in Banff, or somewhat later in Jasper. The dates of migration are probably influenced by the rate of thaw on lakes in the lower valleys and by weather conditions both in the parks and in the areas through which waterfowl migrate before arriving in the parks.

The peaks of American Coot migration in Banff in 1977 were in mid and late May while in 1978 the peaks were in late April and early May (Figure 4.13). In 1977 American Wigeon were common, peaking in Jasper at 50 birds on 23 April. In 1978 the peak was 31 on 4 April. In 1979 there were very few wigeons and the highest count

Figure 4.4. Mallard, spring and fall migration in Banff and Jasper.

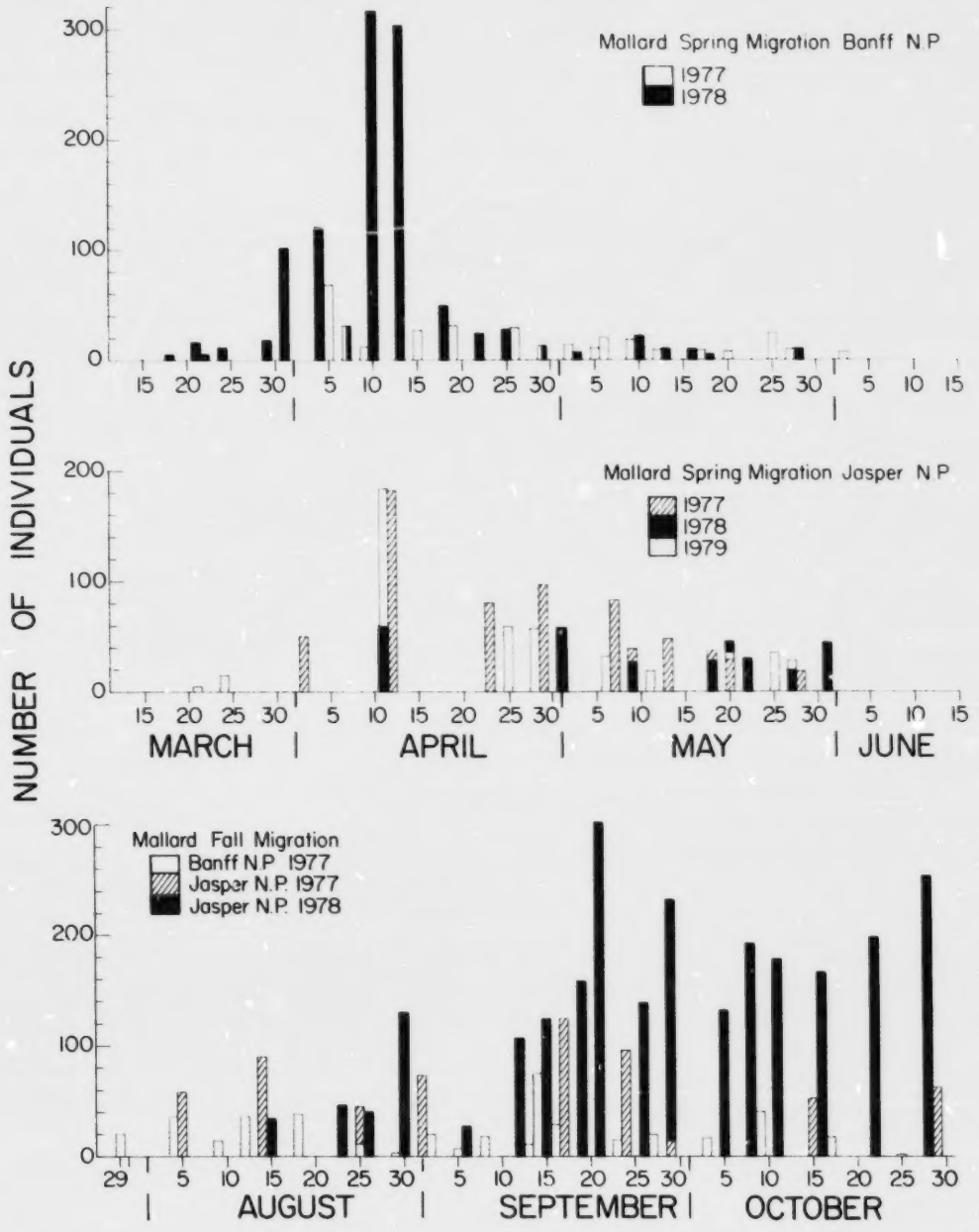


Figure 4.5. Canada Goose, spring and fall migration in Banff and Jasper.

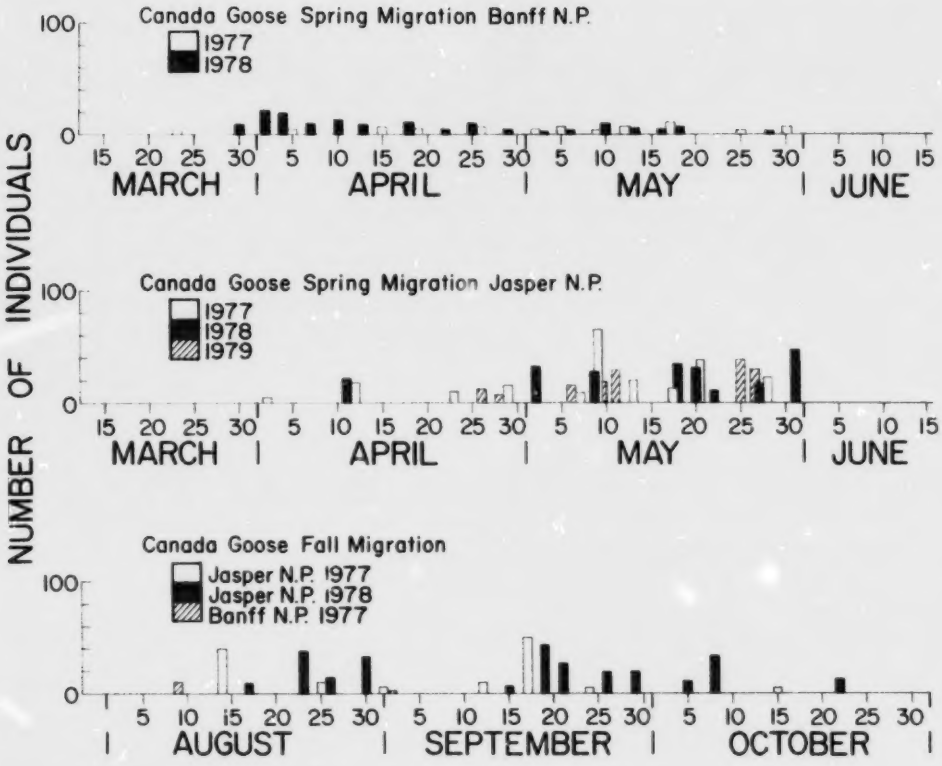


Figure 4.6. Pintail, spring and fall migration in Banff and Jasper.

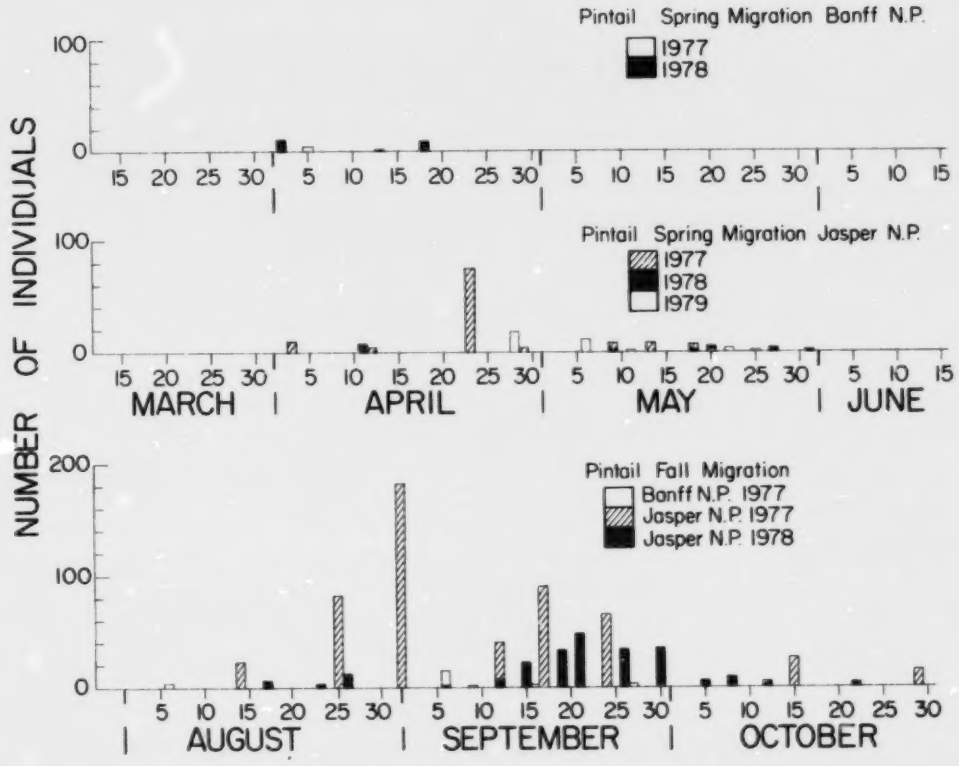


Figure 4.7. American Wigeon, spring and fall migration in Banff and Jasper.

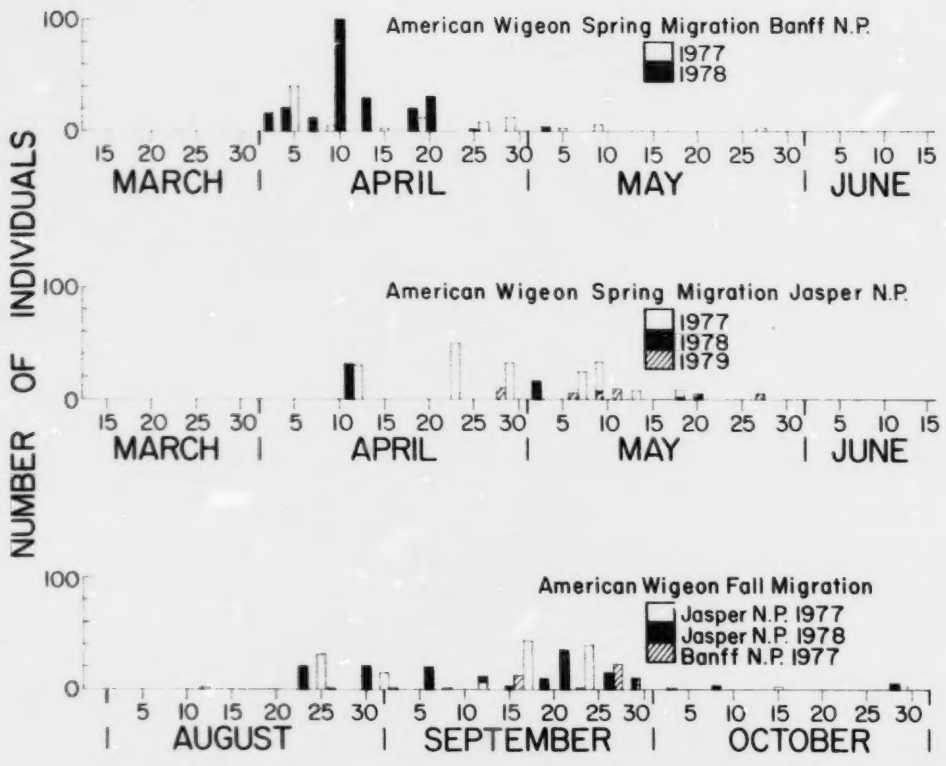


Figure 4.8. Common Goldeneye, spring and fall migration in Banff and Jasper.

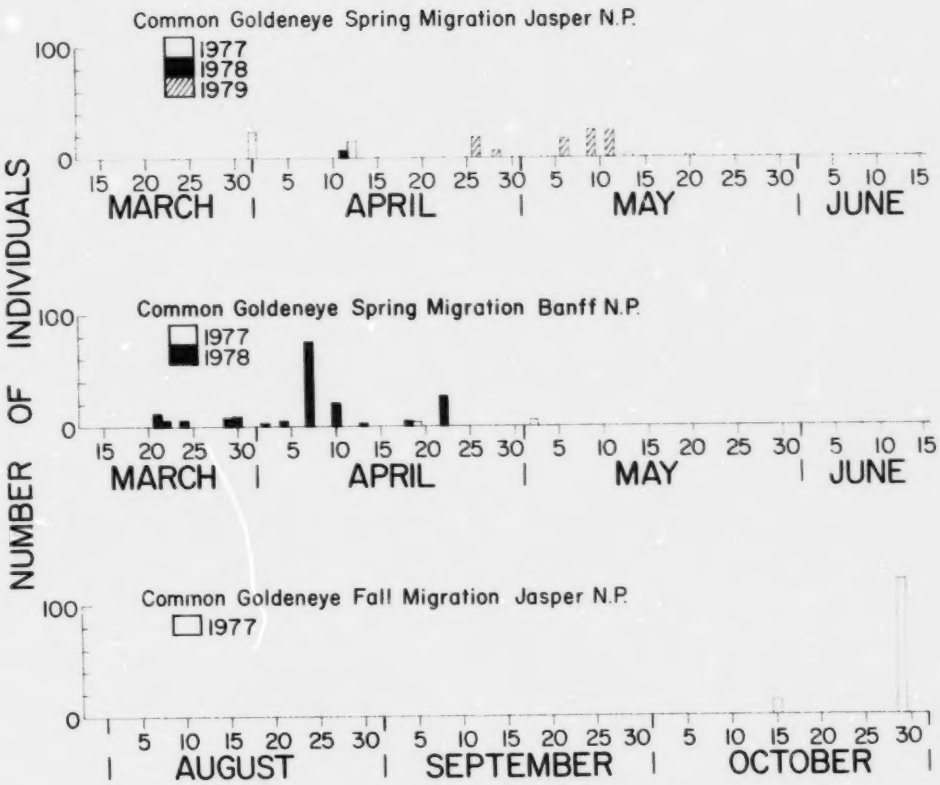


Figure 4.9. Green-winged Teal, spring and fall migration in Banff and Jasper.

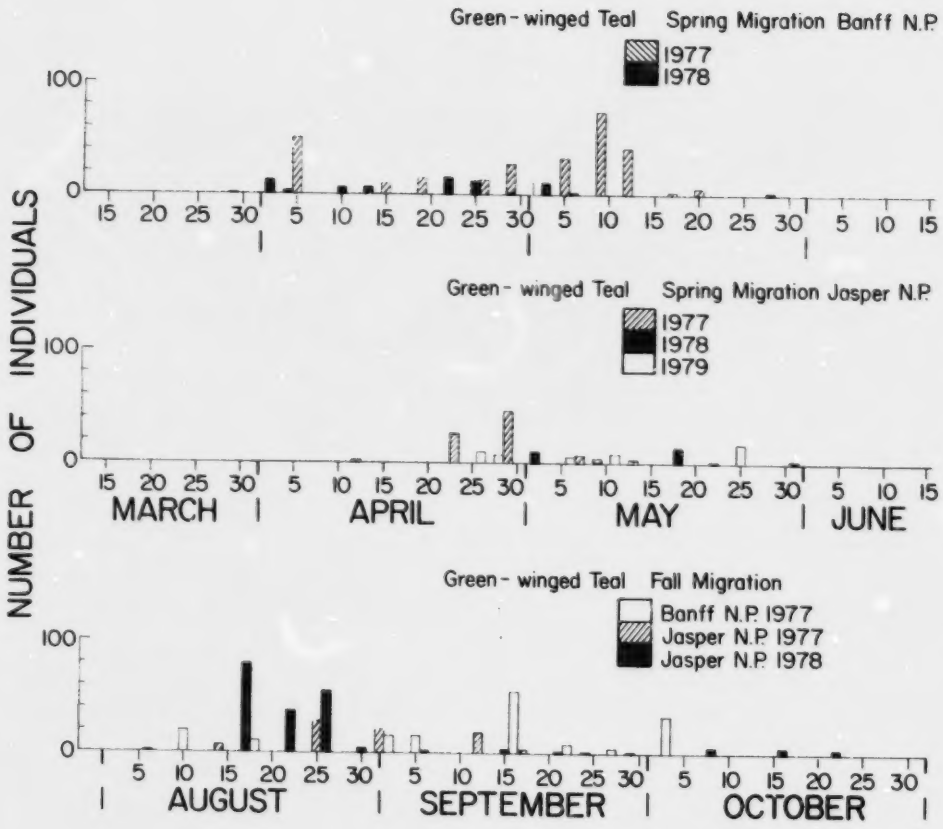


Figure 4.10. Lesser Scaup, spring and fall migration in Banff and Jasper.

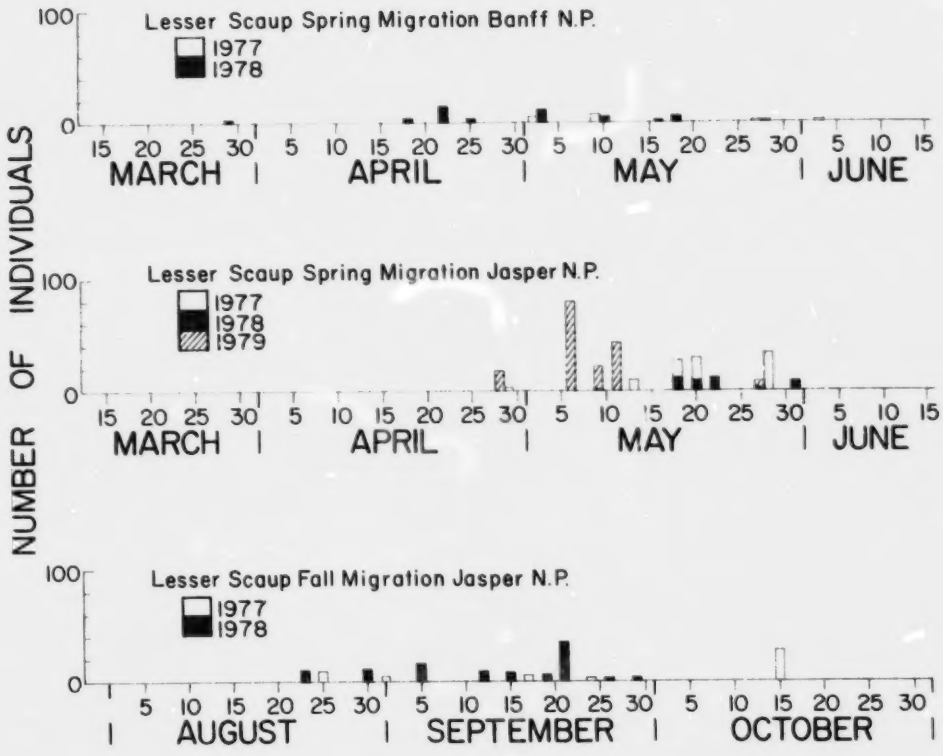


Figure 4.11. Barrow's Goldeneye, spring and fall migration in Banff and Jasper.

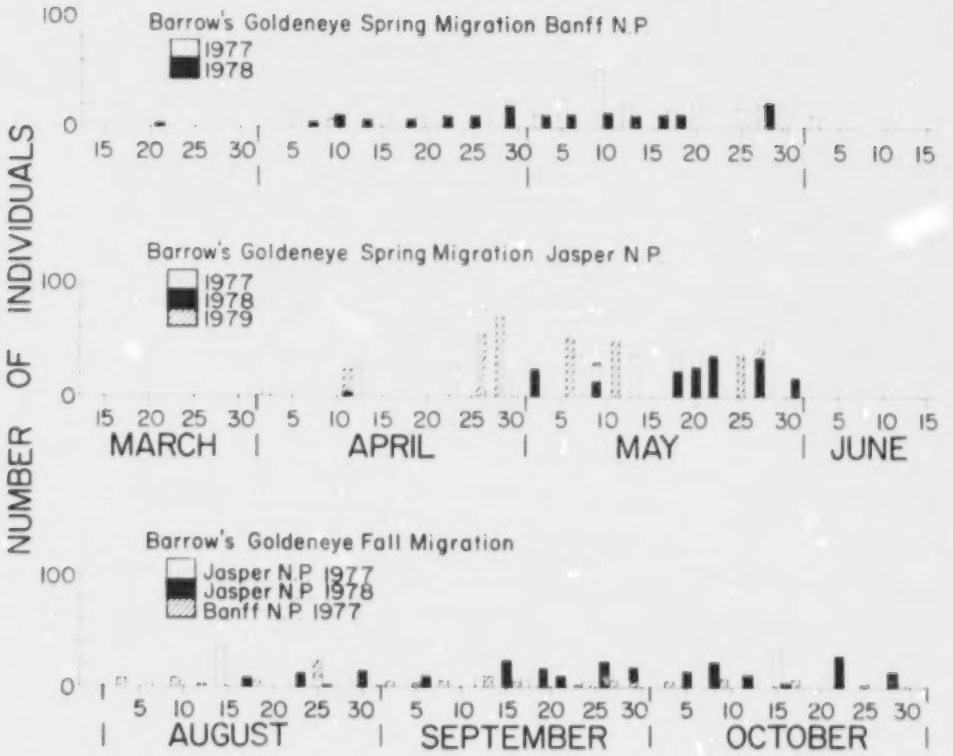


Figure 4.12. Red-necked Grebe, spring and fall migration in Banff and Jasper.

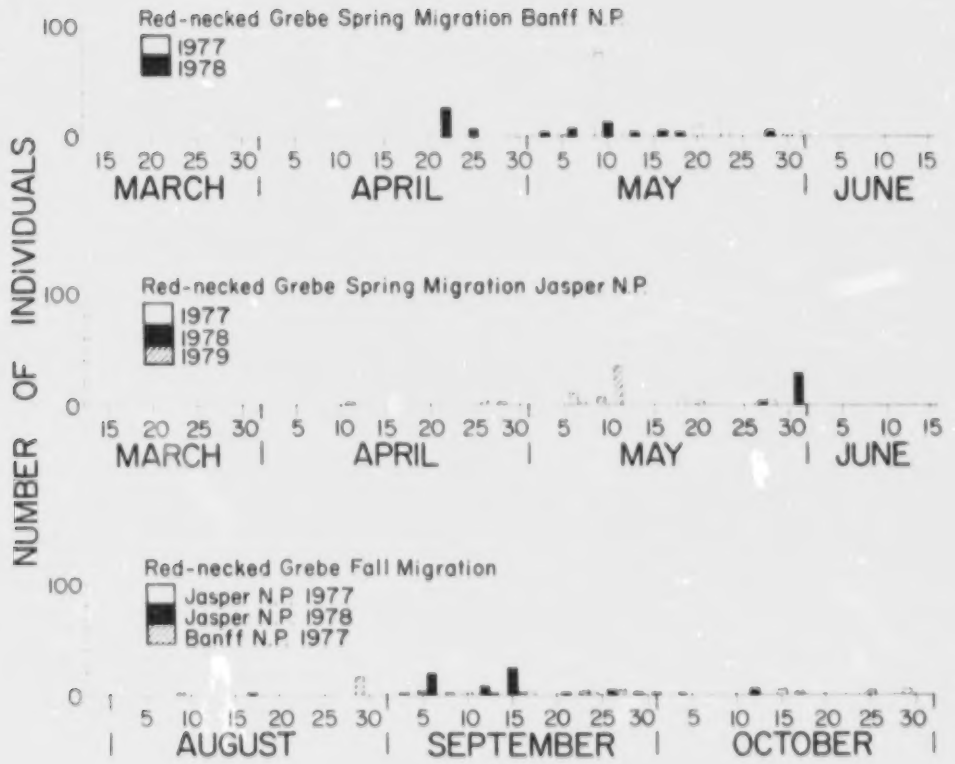


Figure 4.13. American Coot, spring and fall migration in Banff and Jasper.

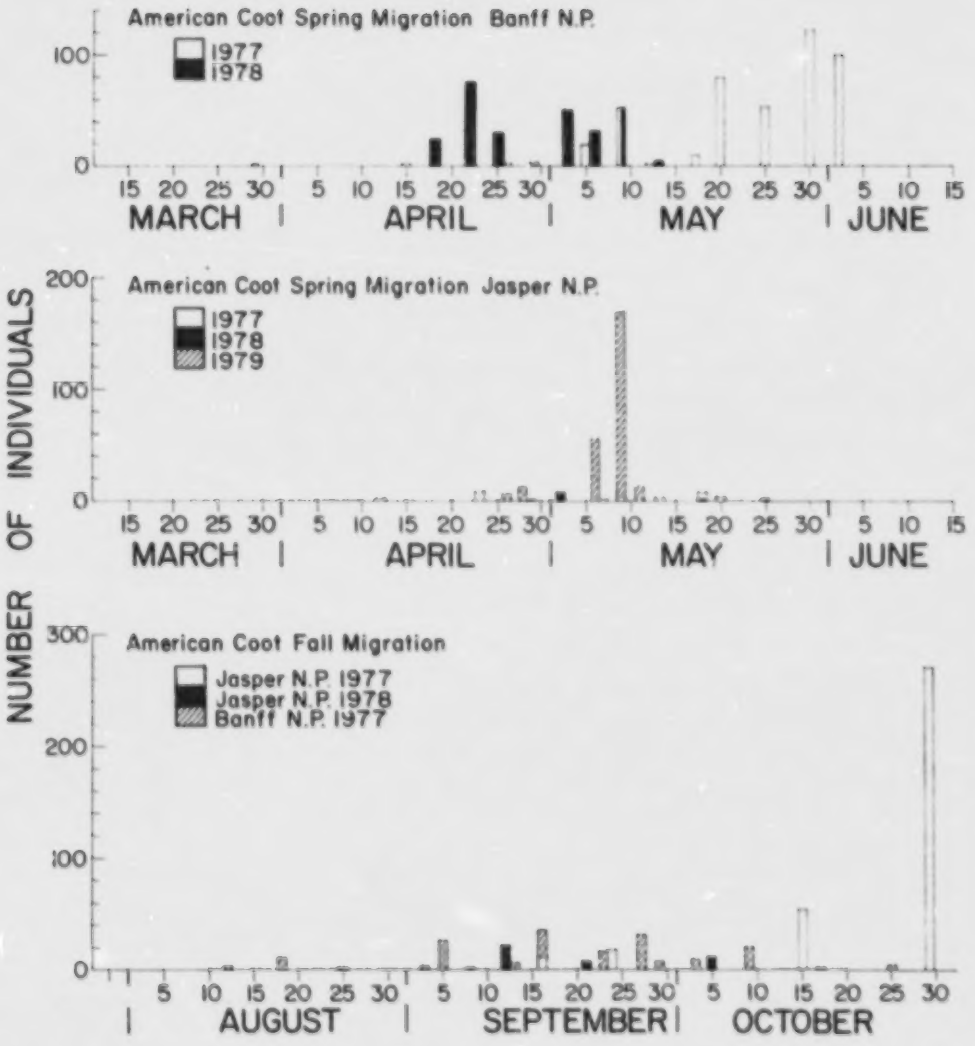


Table 4.1 Comparison between Banff and Jasper of the relative abundance of waterfowl on spring surveys.

Species	Banff National Park		Jasper National Park	
	# recorded	% of total	# recorded	% of total
Mallard	1418	34.4	1416	23.6
Barrow's Goldeneye	451	10.9	886	14.8
Canada Goose	188	4.6	569	9.5
American Wigeon	318	7.7	279	4.7
Bufflehead	105	2.5	464	7.7
Green-winged Teal	352	8.5	165	2.8
Western Grebe	50	1.2	332	5.5
Lesser Scaup	57	1.4	301	5.0
Red-necked Grebe	244	5.9	104	1.7
Common Goldeneye	177	4.3	135	2.3
Blue-Winged Teal	88	2.1	223	3.7
Ring-necked Duck	193	4.7	80	1.3
Horned Grebe	99	2.4	149	2.5
Common Merganser	123	3.0	100	1.7
Pintail	24	0.6	174	2.9
Common Loon	36	0.9	150	2.5
Northern Shoveler	48	1.2	110	1.8
White-winged Scoter	18	0.4	111	1.9
Surf Scoter	5	0.1	104	1.7
Oldsquaw	0	0	67	1.1
Ruddy Duck	43	1.0	15	0.3
Cinnamon Teal	25	0.6	23	0.4
Hooded Merganser	16	0.4	10	0.2
Canvasback	11	0.3	7	0.1
Pied-Billed Grebe	15	0.4	0	0
Redhead	6	0.1	3	0.1
Harlequin Duck	0	0	9	0.2
Eared Grebe	7	0.2	0	0
Gadwall	5	0.1	2	0.03
Whistling Swan	0	0	6	0.1
Scoter (unid.)	3	0.1	0	0
Snow Goose	2	0.05	0	0

was 10 on 28 April (Figure 4.17).

It can be assumed that in most cases these fluctuations in timing and magnitude are caused by extraneous factors such as weather conditions, winter survival of waterfowl populations, and moisture conditions in other areas.

The variations in migration at different elevations are not readily assessed with our data, since there is so much inherent variability and since the only survey routes that adequately censused waterfowl are in the montane ecoregion. Waterfowl congregate in low-elevation water bodies early in the spring and those species that breed in the higher elevations, such as Green-winged Teal, Barrow's Goldeneye and Harlequin Duck, disperse into the higher valleys as open water becomes available.

Shorebirds

Spring migration of shorebirds through Banff and Jasper is relatively small-scale both in terms of numbers of species and numbers of individuals. The total number of species recorded in spring censuses was 11; of these, 5 (Killdeer, Common Snipe, Spotted Sandpiper, Solitary Sandpiper, and Greater Yellowlegs) are summer residents of the parks, and 4 (Upland Sandpiper, Baird's Sandpiper, Wilson's Phalarope and Northern Phalarope) were recorded on fewer than 3 individual censuses and are not considered regular spring migrants. No shorebird species are common or fairly common by the New York State standards of abundance.

When all documented records are considered only 14 species of shorebirds have been observed in spring in Banff and Jasper. Most shorebirds are seen during May and early June; only the Killdeer and Common Snipe arrive during April. Regular migrants include these two species as well as Spotted Sandpiper, Solitary Sandpiper, Greater Yellowlegs and, possibly, Baird's Sandpiper and Pectoral Sandpiper. Most other species occur only sporadically or accidentally, probably as a result of being forced off course and grounded by foul weather.

There are insufficient data to meaningfully compare shorebird migration in Banff with that in Jasper.

Passerines and terrestrial non-passerines

During the 1977 spring migration surveys 75 species were recorded, of which 65 were migrants. Of these migratory species 14 were recorded in Banff but not in Jasper, and 4 in Jasper but not in Banff.

Taking into account all documented records, 115 species have been recorded in Banff and Jasper in spring, of which 98 can be considered migratory. Of the migratory species 15 have been recorded in Banff only and 5 in Jasper only.

In spite of the reasonably high number of species encountered on spring surveys in Banff and Jasper, none are considered abundant and only 3 are very common by the New York State standards of abundance. There are 15 common species. Since these standards were designed to be applicable throughout North America, it is evident that Banff and Jasper are not on major migration routes.

Over half of the total individuals recorded on spring surveys were of seven species; the three commonest species, American Robin, Dark-eyed Junco and Yellow-rumped Warbler, accounted for 31% of all the terrestrial birds counted (Table 4.2). These species are among the commonest spring migrants elsewhere in Alberta too (Salt and Salt 1976).

There is a gradual increase in the number of species observed as spring progresses. In 1977 and 1978 during the period 15 April to 30 May the increase in the number of species from one week to the next averaged from 8 on the Maligne route in 1977, to 28 on the Vermilion-Minnewanka route in 1978. The average increase over all routes was 16 species (Figures 4.2 and 4.3).

The maximum number of species recorded on a single count averaged 31 over the 10 routes, ranging from 15 on the Talbot Lake route in 1977 to 48 on the Vermilion-Minnewanka route in 1978. There were two major periods when influxes of migrants were recorded: mid to late April, and mid May. The timing of these influxes

varied somewhat from year to year and on different routes.

The earlier of the more common migrants, seen consistently by mid April, include the Common Flicker, Black-billed Magpie, Common Crow, American Robin, Varied Thrush, Swainson's Thrush, Mountain Bluebird, Townsend's Solitaire, Golden-crowned Kinglet, Bohemian Waxwing, Common Starling, Dark-eyed Junco and Song Sparrow (Figures 4.14, 4.15, 4.16, 4.17). Most other species, insectivorous ones in particular, arrive between the last week of April and late May (Figures 4.18, 4.19, 4.20). The latest migrants, arriving in late May, include the Willow, Alder and Olive-sided Flycatchers, Blackpoll Warbler, and the main influx of Chipping Sparrows (Figure 4.21).

Comparison of spring migrations in Banff and Jasper

Most spring migrants are of comparable relative abundance in Banff and Jasper or somewhat less abundant in Jasper (Table 4.2). Two species, however, differ dramatically between parks. The Red-winged Blackbird is much more common in Banff, mostly because there is more suitable habitat for the species there. The Water Pipit is more common in all the areas surveyed in Jasper than in Banff.

Almost all of the 40 spring migrant species which exceeded a maximum count of 10 on any one survey displayed at least one peak in numbers, followed by a subsequent sustained drop below half the peak. This indicates that the Bow River valley and the Athabasca River and Maligne River valleys are used as migration routes by most species. The exception to this pattern are the Swainson's Thrush and Northern Yellowthroat whose numbers peak in late May and early June, implying either that the main migration routes of these species bypass Banff and Jasper and only resident populations are observed on migration surveys, or that they are late migrants.

The origin of the birds that summer in Banff and Jasper is unknown, both with regard to their wintering areas and their migration routes outside the parks. No banding programs have been conducted in Banff or Jasper. It is probable that most of the birds that return to Banff and Jasper in the summer migrate north across the prairies and foothills and disperse along major river valleys and over low passes, with many of the birds seen in these parks in spring continuing into the northern Rocky Mountains and BC. Others, particularly western species such as Clark's Nutcracker, Varied Thrush and Townsend's Warbler, probably enter Banff and Jasper over low passes and along valleys from the west.

The Bow River valley is an important staging area for Banff migrants. Of the 12,824 birds recorded on migration surveys in 1977 in Banff and Jasper, 65% were recorded in Banff. In addition, 60 species were recorded in Banff as opposed to 50 in Jasper. Since migration survey routes in both parks sample similar habitats and since these habitata are generally more extensive and more heavily sampled in Jasper than in Banff, it is apparent that the Bow valley is a more important migration route than the Athabasca or Maligne valleys and is probably the most important valley in the park for most migrants. Other important valleys in this regard include the Red Deer River, North Saskatchewan River and Brazeau River valleys.

Although these valleys are important migration routes in the context of Banff and Jasper, the magnitude of migration of most species indicates that these valleys are not part of any major continental migration route. Although some of the birds observed in Banff and Jasper are migrating through the parks, most are probably concentrated in the major valleys in advance of dispersal into other valleys at higher elevations.

Latitude, elevation and yearly variations in migration

Earliest arrival and peak migration of most species is later in Jasper than in Banff. The inital major peak of 16 of the most common migrants averaged about 7 days earlier in Banff than in Jasper. This average includes a wide range of variation; Ruby-crowned Kinglets peaked 4 days later in Banff and Pine Siskins peaked 27 days earlier.

Figure 4.14. Varied Thrush, spring migration in Banff and Jasper.

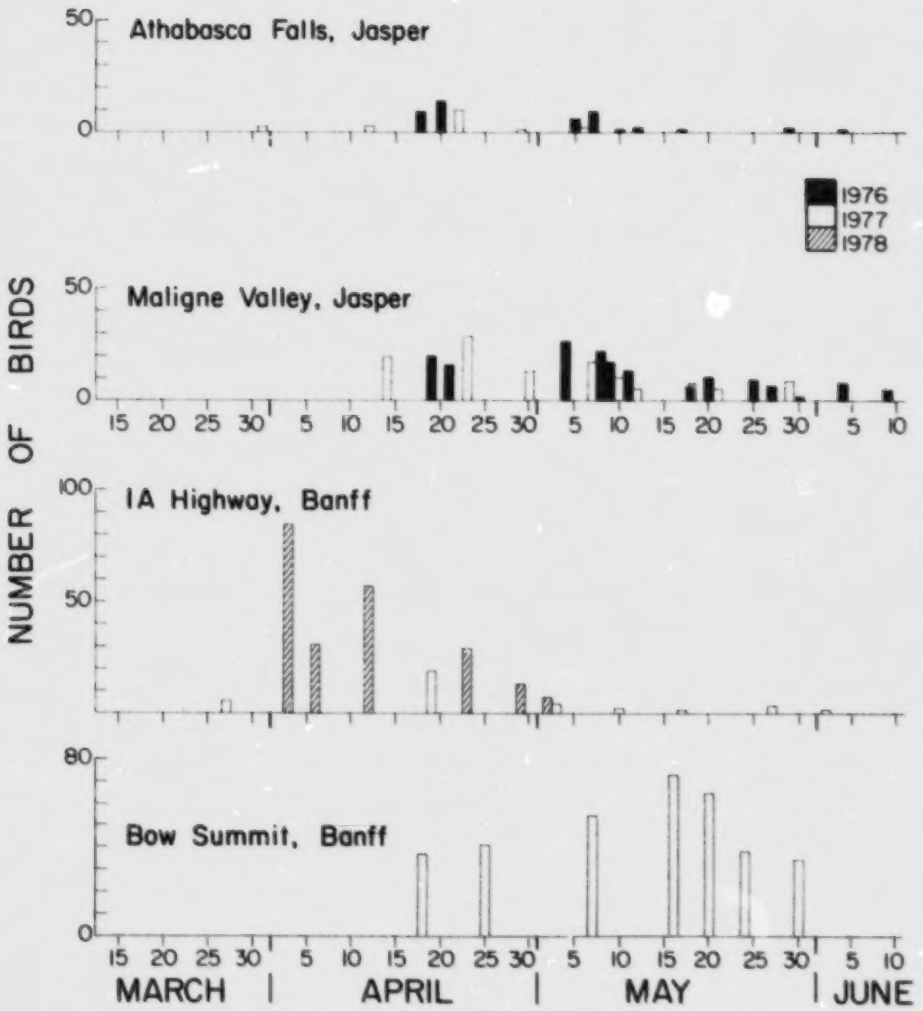


Figure 4.15. American Robin, spring migration in Banff and Jasper.

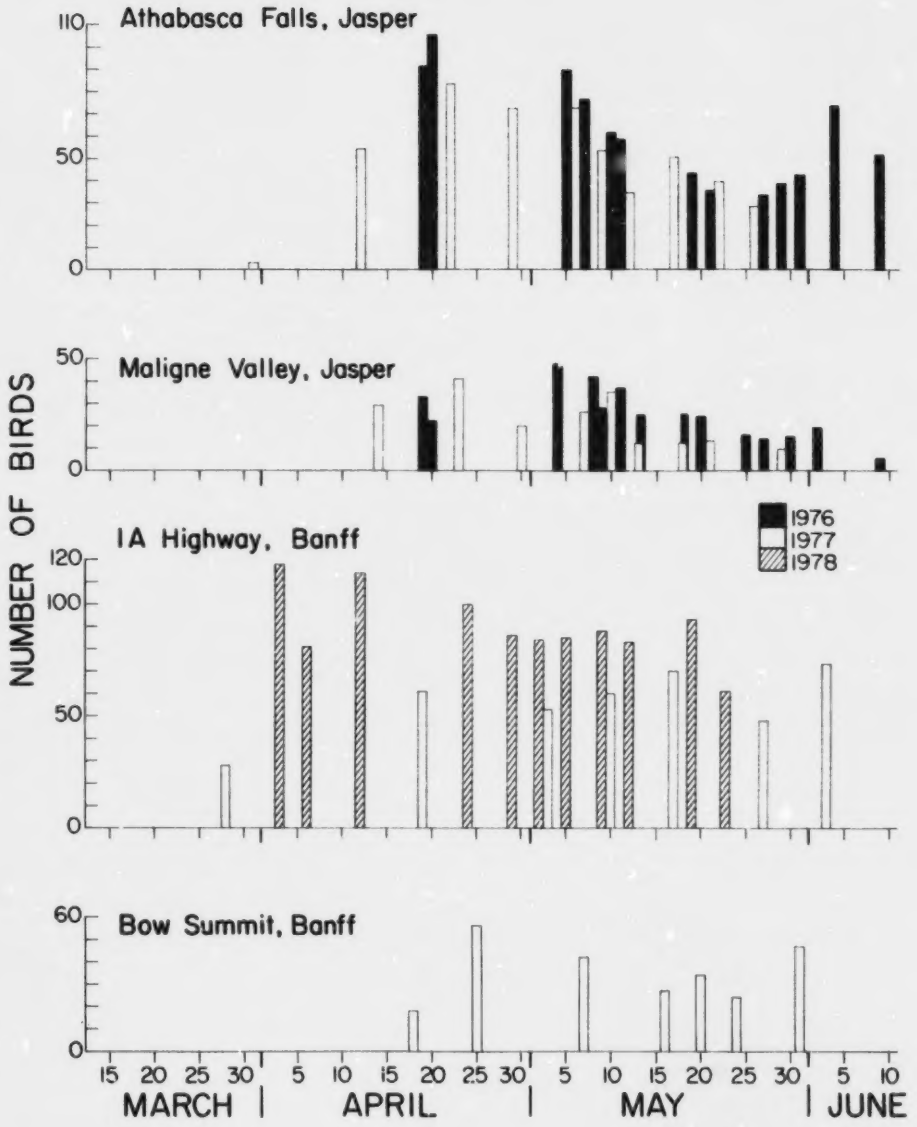


Figure 4.16. Red-winged Blackbird, spring migration in Banff and Jasper.

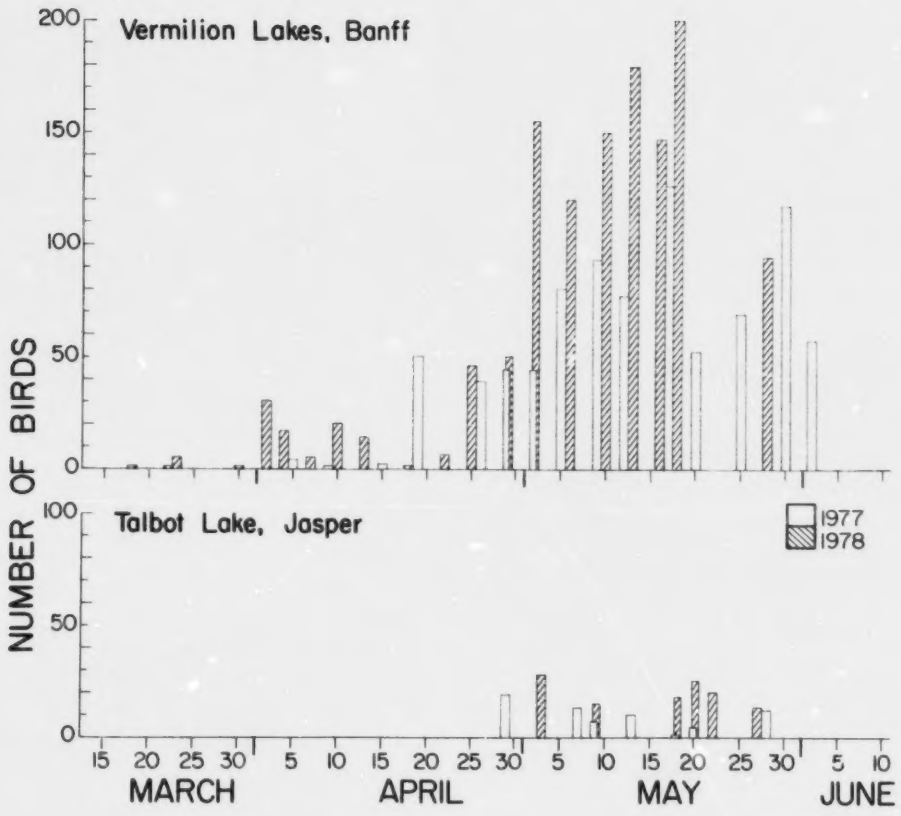


Figure 4.17. Dark-eyed Junco, spring migration in Banff and Jasper.

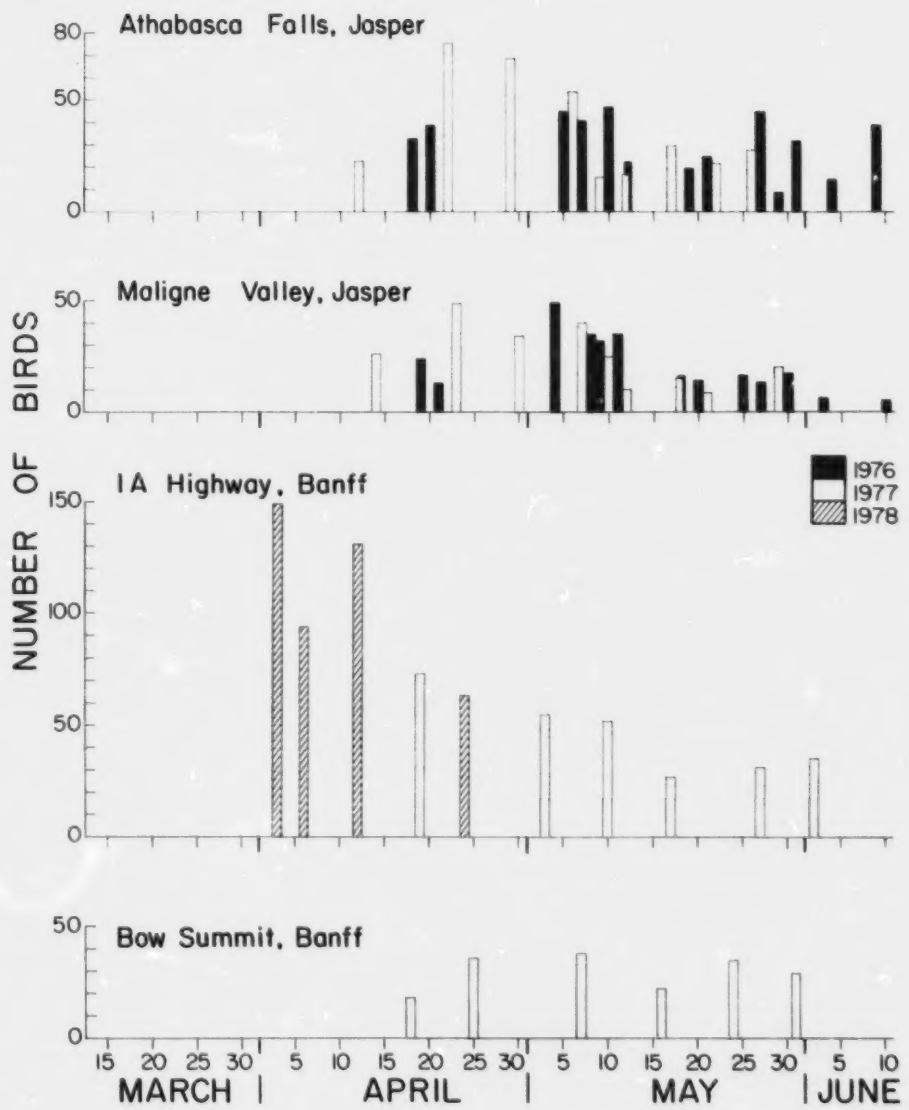


Figure 4.18. Ruby-crowned Kinglet, spring migration in Banff and Jasper.

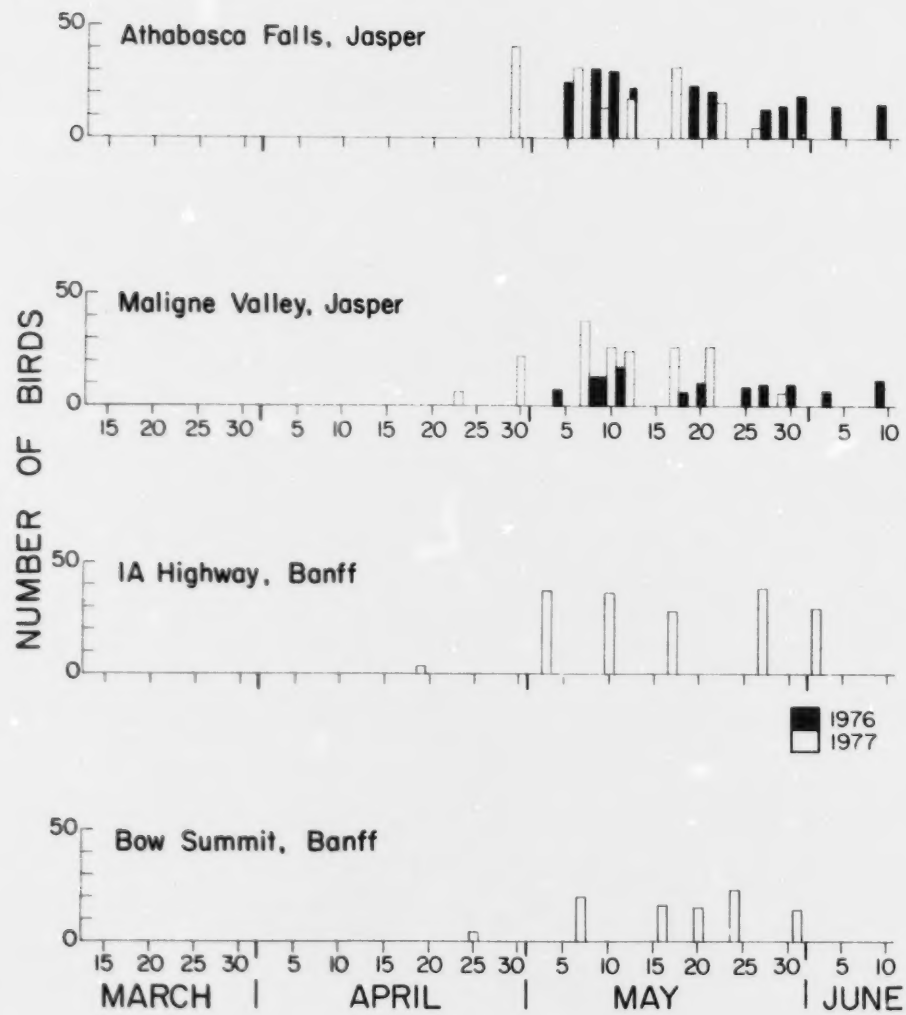


Figure 4.19. Yellow-rumped Warbler, spring migration in Banff and Jasper.

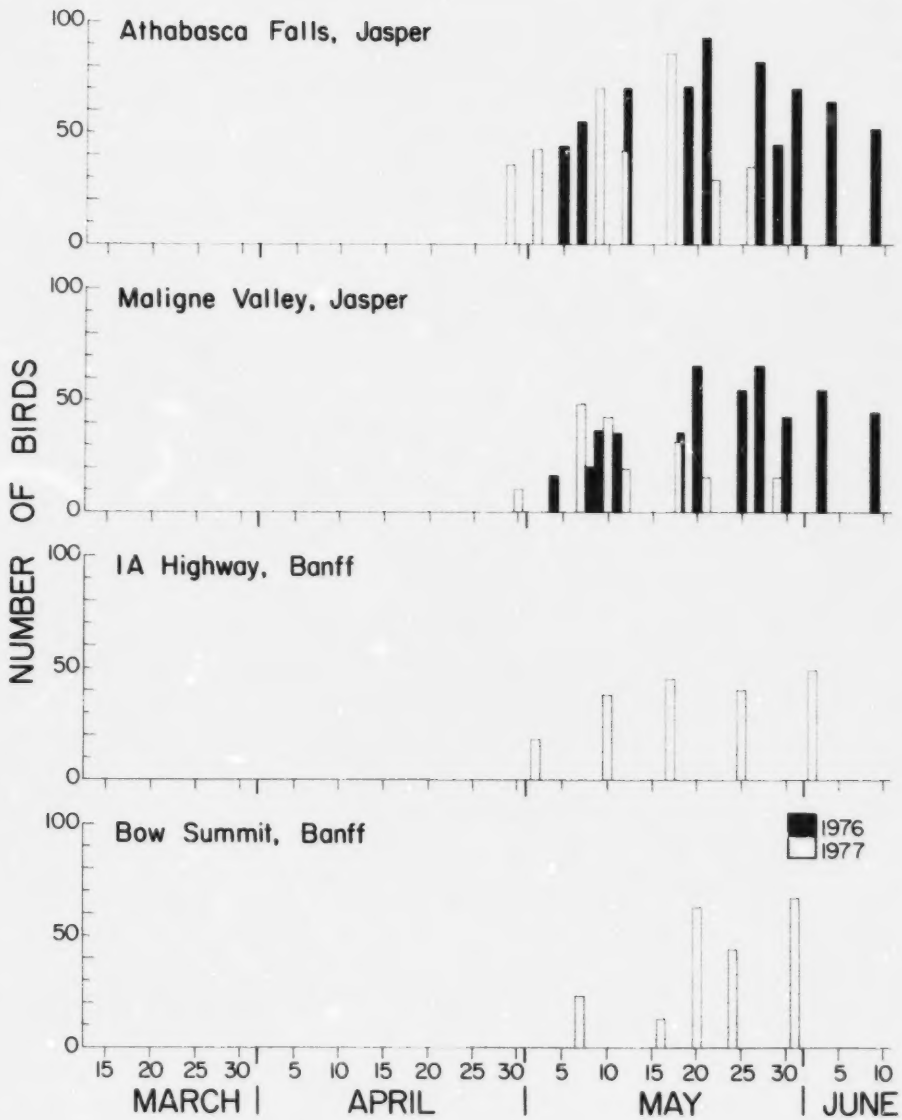


Figure 4.20. Pine Siskin, spring migration in Banff and Jasper.

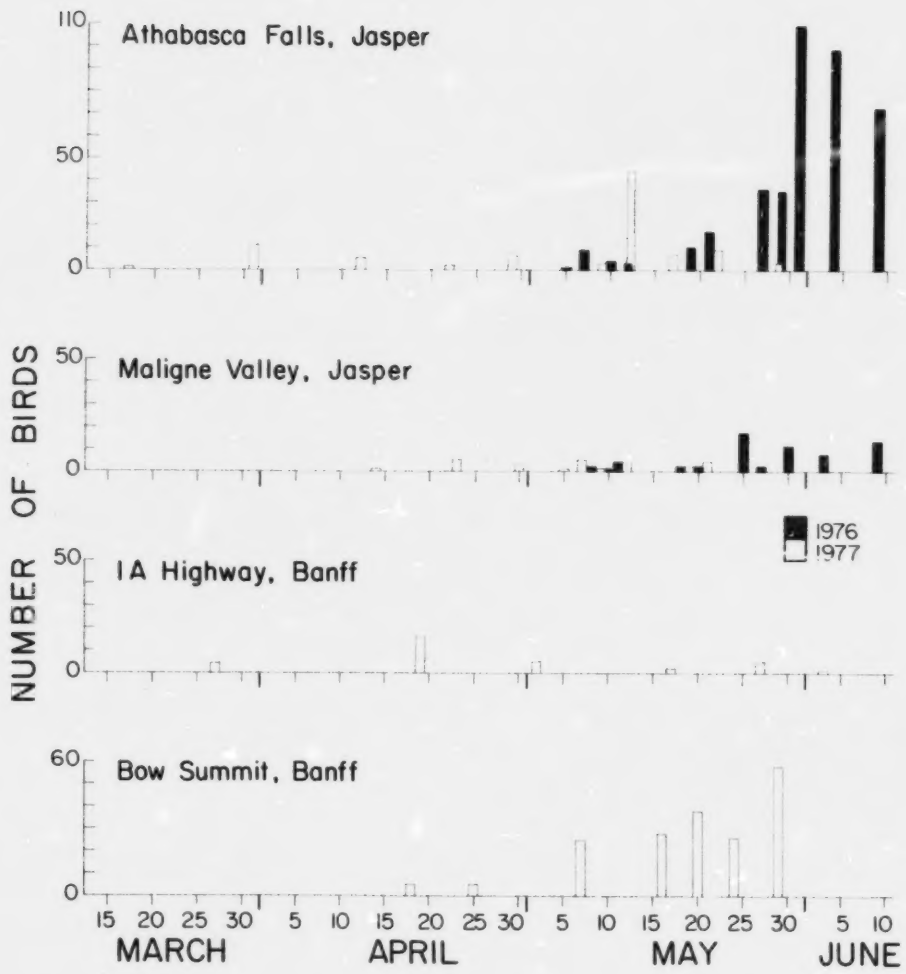


Figure 4.21. Chipping Sparrow, spring migration in Banff and Jasper.

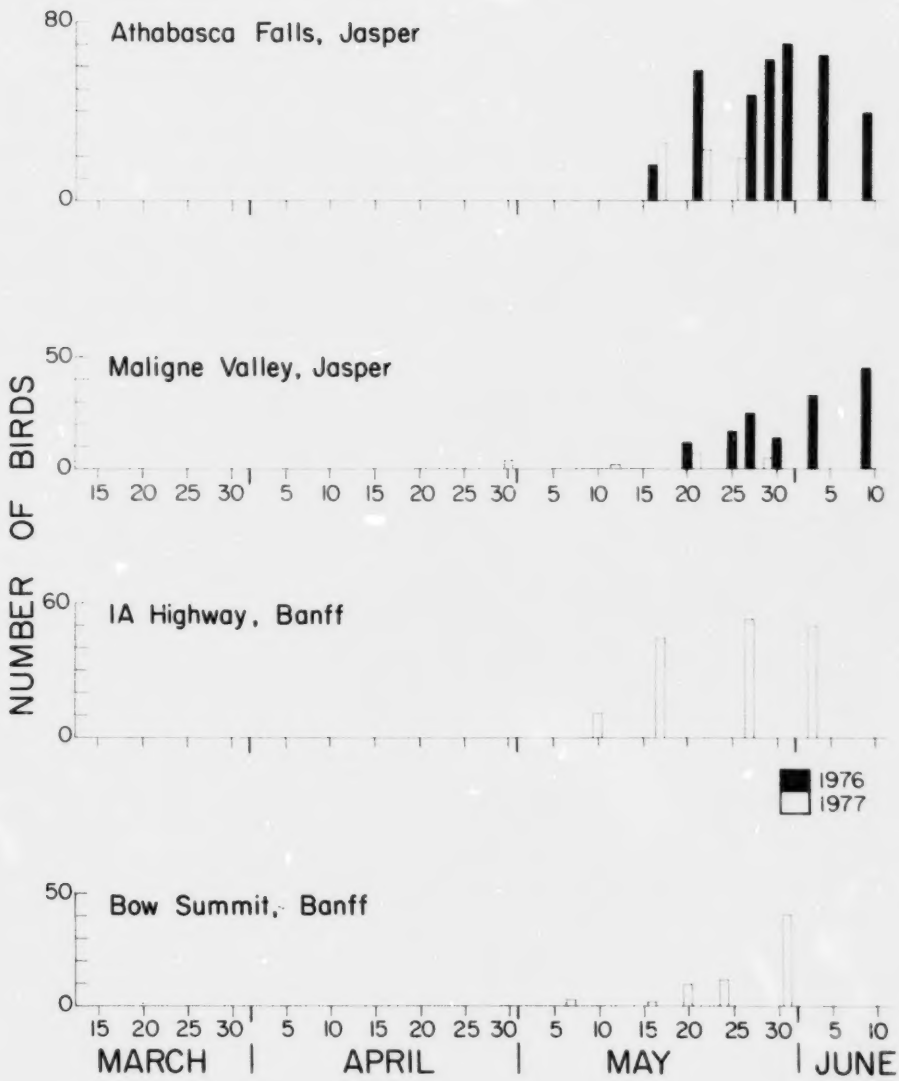


Table 4.2. Comparison between Banff and Jasper of the relative abundance of the most common birds on spring surveys along three comparable routes.*

Species	Banff National Park # recorded	% of Total	Jasper National Park # recorded	% of Total
American Robin	951	11.4	656	14.6
Dark-eyed Junco	674	8.1	553	12.3
Yellow-rumped Warbler	590	7.1	488	10.9
Red-winged Blackbird	656	7.9	66	1.5
Ruby-crowned Kinglet	328	3.9	325	7.2
Varied Thrush	487	5.8	143	3.2
Pine Siskin	399	4.8	118	2.6
Water Pipit	63	0.8	416	9.3
Chipping Sparrow	332	4.0	86	1.9
Bohemian Waxwing	200	2.4	213	4.7
Common Crow	227	2.7	146	3.3
Common Raven**	135	1.6	178	4.0
Cliff Swallow	275	3.3	4	0.1
Gray-crowned Rosy Finch	240	2.9	22	0.5
Golden-crowned Kinglet	146	1.8	95	2.1
Common Flicker	125	1.5	70	1.6
Brown-headed Cowbird	152	1.8	23	0.5
Tree Swallow	132	1.6	42	0.9
Gray Jay**	115	1.4	57	1.3
Ruffed Grouse**	87	1.0	77	1.7
Townsend's Solitaire	69	0.8	93	2.1
Black-capped Chickadee**	148	1.8	13	0.3
White-crowned Sparrow	152	1.8	5	0.1
Rough-winged Swallow	152	1.8	4	0.1
Black-billed Magpieilled magpie**	137	1.6	18	0.4
Mountain Chickadee**	128	1.5	16	0.4
Common Starling	95	1.1	47	1.0
Boreal Chickadee**	91	1.1	38	0.8

*Refer to methods for details (section 2.2).
**Resident species

Most species arrive and peak later at higher elevations than in the valley bottoms. In Jasper, the Athabasca Falls survey route averages 275 m lower than the Maligne valley route (1040-1250 m, 1160-1680m). In 1977 the initial migration peaks of 12 species that exhibited peaks on both routes (Red-breasted Nuthatch, American Robin, Varied Thrush, Swainson's Thrush, Townsend's Solitaire, Golden-crowned Kinglet, Ruby-crowned Kinglet, Water Pipit, Yellow-rumped Warbler, Pine Siskin, Dark-eyed Junco, and Chipping Sparrow) averaged 8 days later in the Maligne valley than along the Athabasca Falls route. Again, variation was high among these species, with Golden-crowned Kinglets peaking 6 days later and Pine Siskins 23 days earlier on the Athabasca Falls route.

The later occurrence of migration at higher elevations is due to cooler temperatures resulting in later snow-lie and green-up. Migrants move northward along the low-elevation valleys before dispersing into and through the higher valleys.

Another variable influencing migration patterns is the unpredictable annual variation of such factors as weather. For example, on the Talbot Lake route there were 30 land bird species recorded in 1977 compared to 44 species in 1978.

4.1.3. AUTUMN MIGRATION

Loons, grebes and waterfowl

During the autumn migration surveys in Banff and Jasper, 28 species of loons, grebes and waterfowl were counted. Although small numbers of Mallards and Common Goldeneyes winter in the parks, all of these species may be considered migratory. One species, the Cinnamon Teal, was observed only in Banff, while 5 species, the Common Goldeneye, White-winged Scoter, Gadwall, Red-breasted Merganser and Whistling Swan, were recorded only in Jasper (Table 4.3).

Taking all documented records into account, 32 species of loons, grebes and waterfowl have been recorded in Banff and Jasper during the autumn migration period. This does not include Harlequin Duck which have usually left the parks before the end of August. Of these species two, Arctic Loon and Brant, have been recorded only in Jasper in autumn and one, Cinnamon Teal, only in Banff.

No autumn migrants are abundant and only the mallard is very common according to the New York State standards of abundance. There are 8 species which are common. This paucity of very common and abundant species indicates that, as in spring, Banff and Jasper are not parts of major migration routes but are probably used mainly as staging areas for local populations and occasional stragglers from east and west of the Rockies. The extent to which the lower mountain passes such as the Yellowhead, Howse and Kicking Horse are used by waterfowl has not been determined.

Numbers of waterfowl recorded on migration surveys begin to increase in late August as newly-fledged broods begin to gather in loose flocks in open water. The first wave of migrants is in late August, with numbers building to a number of peaks between mid-September and mid-October. The appearance of ice along lakeshores and shallows in late October signals the beginning of a drastic decline in the numbers of waterfowl present, until by freeze-up in the first week or two of November, only a few mallards, goldeneyes and, occasionally, grebes remain. Late grebes and loons are occasionally trapped in the ice during November cold snaps on Talbot Lake and Vermilion Lakes; when the ice becomes firm enough these are eaten by coyotes or other scavengers.

The earliest migrants from the parks are Harlequin Ducks, which are rarely seen after the last week in August.

The next group of migrants to depart includes Red-necked Grebes, Canada Geese, Pintails, Green-winged Teals, American Wigeons and Lesser Scaups (Figures 4.5, 4.6, 4.7, 4.9, 4.10). These species begin to increase in late August and peak in the middle of September. Numbers then decline until by early October most have departed.

Mallards, Barrow's Goldeneyes and, some years, American Coots (Figures 4.4, 4.11, 4.13) begin to increase in late August and the numbers observed along the Bow and lower Athabasca River valleys fluctuate throughout the autumn, reaching their highest levels in mid or late October, then decreasing dramatically with the onset of freezeup.

While pintails are considerably more abundant in the autumn than in spring, and Buffleheads, Common Mergansers and Hooded Mergansers are somewhat more abundant in autumn, most species occur in lesser numbers in autumn than in spring (Tables 4.1 and 4.3). This is in spite of the fact that their numbers have been augmented by young

Table 4.3. Comparison between Banff and Jasper of the relative abundance of waterfowl on autumn surveys.

Species	Banff National Park # recorded	% of total	Jasper National Park # recorded	% of total
Mallard	367	25.2	3409	47.2
Pintail	28	1.9	761	10.5
Barrow's Goldeneye	119	8.2	357	4.9
Common Goldeneye	45	3.1	413	5.7
American Wigeon	49	3.4	393	5.4
Green-winged Teal	164	11.3	273	3.8
Canada Goose	11	0.7	376	5.2
Bufflehead	5	0.3	348	4.8
Ring-necked Duck	350	24.0	2	0.03
Common Loon	12	0.8	151	2.1
Hooded Merganser	112	7.7	48	0.6
Lesser Scaup	5	0.3	147	2.0
Blue-Winged Teal	36	2.5	101	1.4
Common Goldeneye	0	-	137	1.9
Red-necked Grebe	40	2.7	78	1.1
Western Grebe	50	3.4	39	0.5
Northern Shoveler	12	0.8	37	0.5
Horned Grebe	8	0.5	39	0.5
Canvasback	3	0.2	41	0.6
Pied-Billed Grebe	28	1.9	2	0.03
Ruddy Duck	3	0.2	25	0.3
Surf Scoter	3	0.2	20	0.3
White-winged Scoter	0	-	11	0.2
Gadwall	0	-	5	0.07
Cinnamon Teal	5	0.3	0	-
Red-breasted Merganser	0	-	5	0.07
Redhead	2	0.2	2	0.03
Whistling Swan	0	-	1	0.01

hatched that summer and indicates that the lower Athabasca and Bow valleys are of greater importance as spring staging areas than as autumn ones.

Autumn waterfowl migration also differs from spring migration with regard to the relative proportions of migrant waterfowl represented by diving and pond ducks (Table 4.3). Pond ducks account for 68.9% of all migrant waterfowl recorded in Jasper in autumn, while diving ducks account for 21.4%. In Banff both groups account for about 45% of the autumn waterfowl migrants. Loons and grebes are more significant in Banff (9.3%) than in Jasper (4.2%), while Canada geese represent 5.2% of Jasper's migration and only 0.7% of Banff's.

Shorebirds

Autumn shorebird migration is of greater magnitude than spring migration, involving more species and more individuals. During autumn migration surveys 16 shorebirds species were observed. Nine of these (Pectoral Sandpiper, Short-billed Dowitcher, Buff-breasted Sandpiper, Northern Phalarope, Black-Bellied Plover, Baird's Sandpiper, Golden Plover, Least Sandpiper, Sanderling) were recorded only in Jasper, and one

(Common Snipe) only in Banff, although it is present in both parks. Only the Lesser Yellowlegs is common by the New York State standards of abundance and no species is very common or abundant, indicating that Banff and Jasper are not major migration areas for shorebirds.

When all documented records are considered there are 24 species of shorebirds that have been observed in Banff and Jasper during the autumn migration. Most records are from August and early September. Only the Killdeer, Common Snipe, Greater Yellowlegs, Lesser Yellowlegs, Baird's Sandpiper, Pectoral Sandpiper and Long-billed Dowitcher linger past the first week of September. Killdeers and snipe occasionally remain in Banff and Jasper in the vicinity of permanent open water and warm springs, but it is unlikely that they survive the winter.

The autumn shorebird migration is more pronounced in Jasper than in Banff, partly because of the greater extent of suitable habitat in the form of exposed mud flats and sand beaches and partly because the Athabasca River is a continuous corridor through the boreal region to the arctic and may be used by dispersing shorebirds to a greater extent than the Bow and Red Deer Rivers which flow through the prairies of southern Alberta. Most of the species recorded in Jasper but not Banff have been observed on fewer than 5 occasions and are not regular migrants.

Jasper Lake, Pocahontas Pond, and the Mile 18 Ponds are major shorebird migration areas in Jasper; in Banff most records are from the Brewster Horse Corrals and Vermilion Lakes.

Passerines and terrestrial non-passerines

During the 1977 autumn migration surveys 88 species were encountered, 69 of these migrating from or through the parks. Of the migrating species, 18 were recorded in Banff but not Jasper, and 8 in Jasper but not in Banff. When all documented records are taken into consideration, a total of 107 species have been recorded in one or both parks in the autumn, compared to 115 species in the spring. Included are 90 species migrating from or through the parks. Of the migratory species, 14 have been recorded in Banff but not in Jasper, and 5 in Jasper but not in Banff (Table 4.4).

In the autumn no migratory species were abundant, and only one species was very common. There were 10 common species. The absence of very common and abundant species indicates that, as in the spring, Banff and Jasper are not within a major migration route.

Five species comprised 49% of the total number of birds encountered; the Bohemian Waxwing is by far the most common autumn migrant and comprised 23% of all observations. The three species that were the most common spring migrants, the Dark-eyed Junco, American Robin and Yellow-rumped Warbler, along with the Pine Siskin were the next most common autumn species (Table 4.4).

There was a gradual decrease in the number of species counted as autumn progressed (Figure 4.23). Within the period 10 August to 30 September, the number of species decreased by 18 (from 35 to 17) on the Banff route and 13 (from 29 to 16) on the Jasper route. The main decreases were in mid August and in early September, with a temporary increase in late September, undoubtedly there is variation with the location and year. After early October, few migrants remained.

The first species to migrate from the parks are mostly gone by the end of August. These include all the flycatchers, Violet-green, Bank, Cliff and Rough-winged Swallow, and Western Tanager. Most of the remaining species migrate from mid August until late September (Figure 4.24). The latest migrants, regularly seen after early October, include the Common Crow, American Robin, Varied Thrush, Water Pipit, Bohemian Waxwing, Brown-headed Cowbird, Gray-crowned Rosy Finch, Pine Siskin, Dark-eyed

Table 4.4. Comparison between Banff and Jasper of the relative abundance of the commonest birds on autumn surveys along two Banff and three Jasper routes.*

Species	Banff National Park		Jasper National Park	
	# recorded	% of total	# recorded	% of total
Bohemian Waxwing	643	15.5	1,354	30.1
Dark-eyed Junco	109	2.6	547	12.2
American Robin	142	3.4	451	10.0
Pine Siskin	139	3.5	378	8.4
Yellow-rumped Warbler	144	3.5	285	6.3
Black-billed Magpie**	369	8.9	24	0.5
Cliff Swallow	350	8.4	3	0.1
Black-capped Chickadee**	237	5.7	107	2.4
Common Crow	201	4.8	41	0.9
Ruby-crowned Kinglet	106	2.6	133	3.0
Common Raven**	163	3.9	49	1.1
Boreal Chickadee**	172	4.1	33	0.7
Northern Yellowthroat	152	3.7	28	0.6
House Sparrow**	178	4.3	0	0.0
Mountain Chickadee**	45	1.1	130	2.9
Golden-crowned Kinglet	35	0.8	96	2.1
Barn Swallow	82	2.0	44	1.0
Red-breasted Nuthatch	18	0.4	107	2.4
Red Crossbill**	2	0.0	114	2.5
White-crowned Sparrow	90	2.2	22	0.5
Chipping Sparrow	14	0.3	86	1.9
Gray Jay**	23	0.6	74	1.6
Belted Kingfisher	67	1.6	20	0.4

*Refer to Methods for details (sec. 2.2).
**Resident species.

Junco, Tree Sparrow, and White-crowned Sparrow (Figure 4.25).

Because most species of birds tend to be considerably less conspicuous in the autumn than in the spring, detection of migration patterns is more difficult. Counts on surveys were lower than in the spring, and there was a maximum count of less than 10 birds for all but 30 of the migratory species. However, the most common species on censuses did exhibit migration peaks with a subsequent decline.

For most of the 30 migratory species for which there was a maximum count of at least 10 birds, there was an appreciable increase in numbers to at least one peak with a subsequent drop. Notable exceptions include Willow Flycatcher, the swallows (except the Barn Swallow) and the Red-winged Blackbird; peaks for these species may have been missed due to their being early migrants. These results indicate that the Bow and Athabasca valleys, where the censuses were conducted, are used as migration routes. However, none of the peaks, except for the Bohemian Waxwing, Dark-eyed Junco and American Robin, were large enough to be considered major migratory influxes. The low magnitude of the autumn migration indicates that Banff and Jasper are not on any major migration route for the continent as a whole.

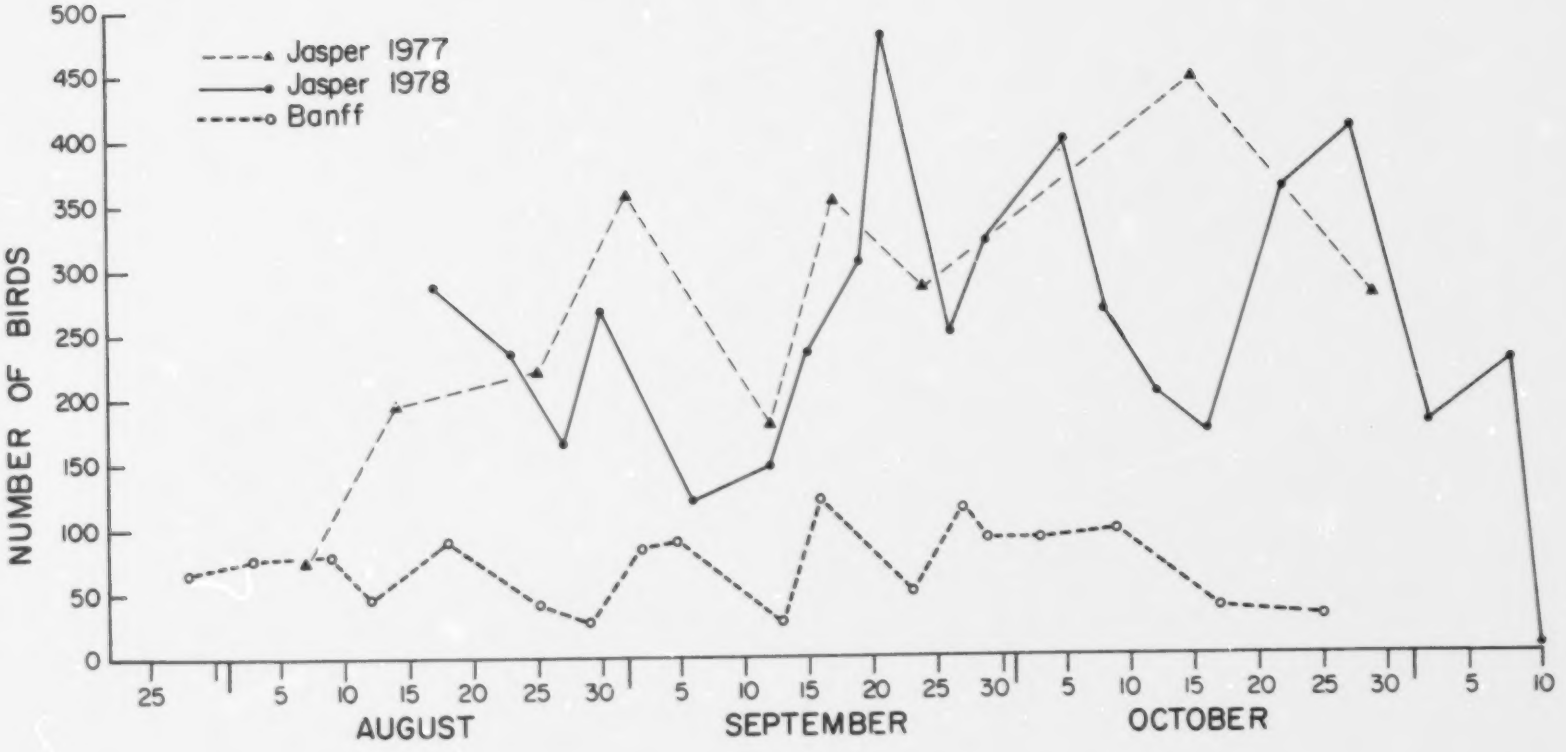


Figure 4.22. Counts of waterfowl on autumn migration surveys in Banff and Jasper.

Figure 4.23. Numbers of species recorded on autumn migration surveys.

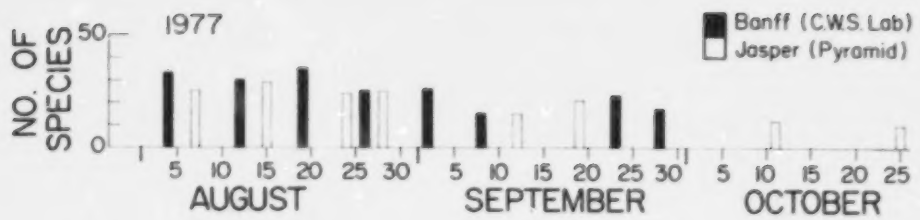


Figure 4.24. Yellow-rumped Warbler and Dark-eyed Junco, autumn migration in Banff and Jasper.

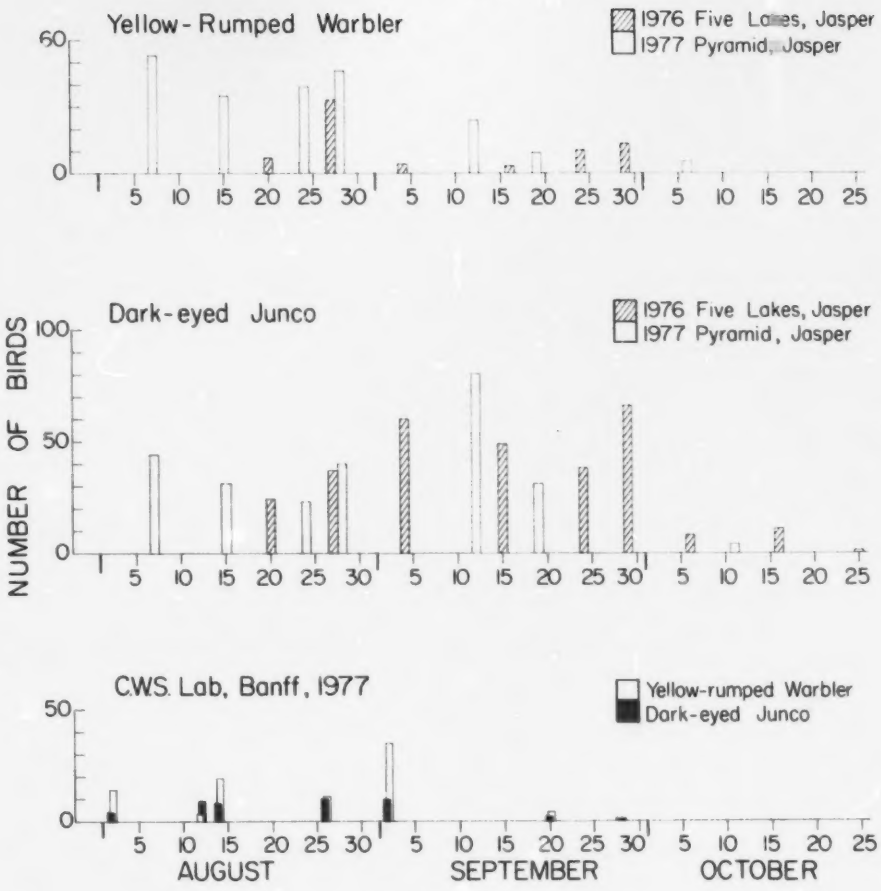
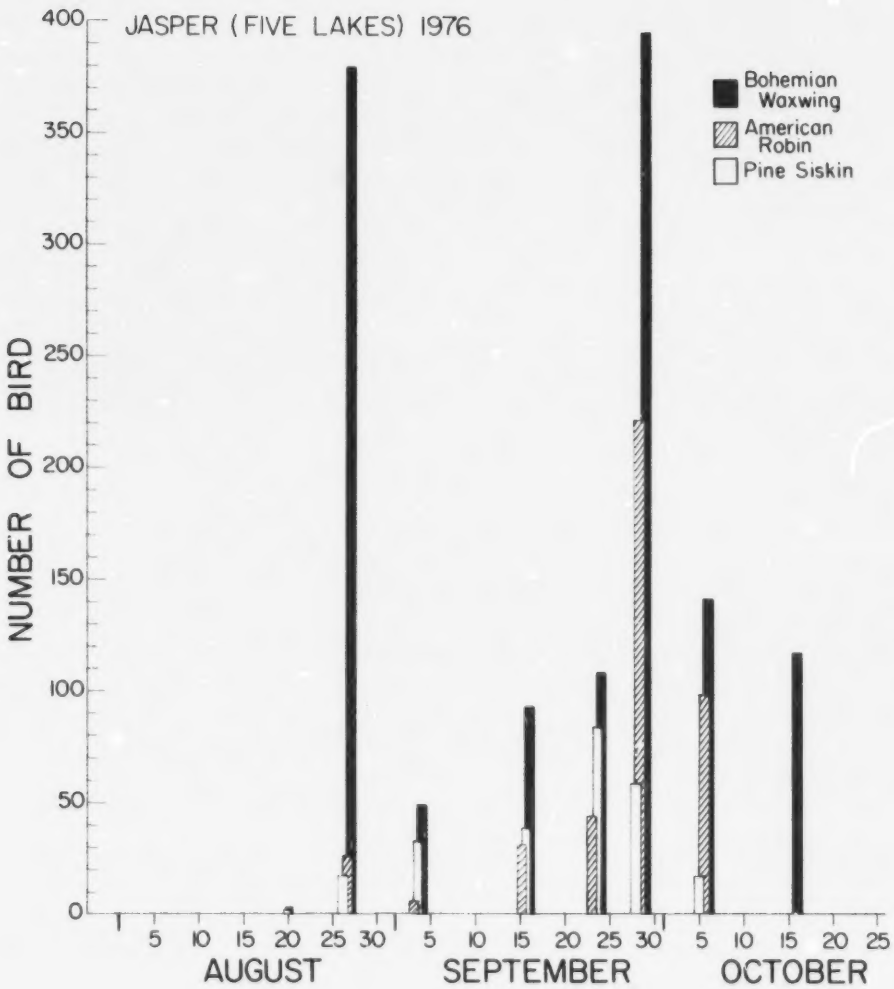


Figure 4.25. Bohemian Waxwing, American Robin and Pine Siskin, autumn migration in Banff and Jasper.



Migrants were about equally common in Banff and Jasper, or somewhat less common in Jasper; about 48% of the 8653 birds on the five 1977 censuses were recorded in Banff, and about 52% in Jasper where almost twice as much sampling effort was expanded. There does not appear to be as major a funnelling of migrants through the Bow valley as there is in the spring. Migrants probably collect in all low-elevation valleys, although more so in the Bow and Athabasca valleys due to their breadth and length.

Because spring and autumn census routes are not directly comparable, and because birds are considerably less conspicuous in the autumn than in spring, it is not possible to compare the magnitude of migration between the two seasons from the data of this study. One difference that does emerge is the greater importance in the spring of the Bow valley, probably due to a channelling of migrants into this low, broad valley as they move northward along the foothills.

Latitude, elevation and yearly changes in migration

As in the spring, there are differences in the timing and magnitude of migration which reflect latitudinal and elevational differences.

The peak Yellow-rumped Warbler migration in Jasper in 1977 was about 1 week earlier than in Banff (27 August and 2 September, respectively). The Dark-eyed Junco migration in Jasper lasted from 12 August until 2 September, with no pronounced peak, while in Banff it averaged two weeks later, lasting from 27 August until 19 September with a pronounced peak on 12 September (Figures 4.24).

In general, the autumn migration data were not sufficient to assess the relative differences in migration between high and low elevations and different latitudes.

4.2. UNGULATE SURVEYS

4.2.1 MOUNT WILSON SURVEY

Introduction

A roadside visual census of Mountain goat and Bighorn sheep in the North Saskatchewan River valley was conducted from 19 May 1978 to 25 May 1979. Surveys were conducted an average of 3 times monthly (39 surveys) and lasted between 1.5 and 3 hours. The survey route extended from the bridge where the Icefields Parkway crosses the North Saskatchewan River, along the Icefields Parkway to the big bend below Parker's Ridge, along the bases of Mounts Wilson and Coleman, Cirrus Mountain, Mount Saskatchewan and Parker's Ridge. Regular stops were made at locations listed on a roadlog (Table 4.5) and all slopes were thoroughly surveyed with binoculars and 20-45X variable spotting scope. All goats and sheep seen were counted and classified, whenever possible, as to age and sex.

An additional survey was conducted by Bell 206B Jet Ranger helicopter on 12 March 1979. During these 40 surveys, 1055 Mountain goat and 189 Bighorn sheep

Table 4.5. Mount Wilson-Coleman ungulate survey route: road log.

Stop #:	*Distance from last stop: kms.*	*miles*	*Location:*
1			North Saskatchewan River (0.1 miles, 0.16 km S of Sask Crossing warden station)
2	3.1	1.9	Glacier Lake trail sign
3	3.3	2.1	Mount Wilson
4	0.8	0.5	Mount Wilson
5	3.7	2.3	Mount Wilson (avalanche slope)
6	2.1	1.3	Mount Wilson (break in trees)
7	4.2	2.6	Rampart Mountain (avalanche slope)
8	1.3	0.8	Norman Creek
9	2.1	1.3	The Castlelets viewpint
10	1.4	0.9	Mount Coleman
11	1.3	0.8	Mount Coleman
12	1.1	0.7	Mount Coleman
13	2.1	1.3	Coleman Creek; Mount Saskatchewan
14	1.1	0.7	Cirrus Mountain
15	0.8	0.5	Cirrus Mountain campground
16	0.5	0.3	Cirrus Mountain campground
17	1.7	1.1	Mount Saskatchewan
18	6.3	3.9	Big Bend; Parker's Ridge

observations were made. Each observation was located on 1:50,000 N.T.S. maps and referenced to habitat on the basis of ecosite and vegetation type. Most sightings were at too great a distance to allow good classified counts and consequently the data do not allow a calculation of herd productivity.

Results and Discussion

1. Mountain goats

a. Population and group sizes

The maximum unduplicated count of goats was 85 on both 24 May 1978 and 2 November 1978. As none of the goats observed on 24 May were young of the year but 11 of the 2 November goats were, the estimated minimum population is 96.

The highest unduplicated count of goats after November was 35. This is considerably less than the known minimum population of 96. This means that up to 61% were not seen in winter. These goats may have been missed because of the difficulty of observing them in snow, or because the majority of the goats leave the area after November and winter on other ranges.

The average group size of goats on Mount Wilson for the survey period was 3.52 (Table 4.6). Generally group size was smaller during the winter months, with an average of 2.73 and an overall low of 1.36 for March. Group size increases from this March low to an average of 4.59 for May, the month

Table 4.6. Monthly counts and age/sex ratios of mountain goats along the Mt. Wilson survey route.

	# of surveys	average # /survey	max. undupl. count	Young/ 100non-young	mean group size
May	5	56.8	90	15 (YLY)	4.73
June	4	15.8	30	4	3.00
July	1	6.0	6	25	3.00
August	4	13.5	32	2	4.50
September	4	19.5	25	5	3.71
October	1	7.0	7	17	2.33
November	4	34.5	85	14	6.50
December	1	34.0	34	17	2.62
January	3	29.7	35	19 (YLY)	3.30
February	1	18.0	18	–	1.64
March	3	5.0	8	7 (YLY)	1.36
April	3	15.7	23	42 (YLY)	3.14
May	5	43.8	66	17 (YLY)	2.73
Annual averages:				14	3.38

showing the largest average group sizes (Figure 4.6). The average group size for the summer months was 3.52.

b. Seasonal habitat use

The lower subalpine is the most important ecoregion to goats along this survey route, receiving 96% of winter use, 87% of summer use, and 90% of year-round use. The upper subalpine is the second most important ecoregion, receiving 4% of winter use, 10% of summer use and 8% of year-round use. Use of the lower subalpine drops in summer and use of the upper subalpine rises as summer vegetation growth opens up more available range.

Goats were recorded in 9 ecosites. SB1 and SB4 were the most important, with 40% and 35% of all sightings respectively. This is partly due to the predominance of these ecosites in the study area.

SB1 and SB4 are most important from May through October, accounting for 90% of all summer sightings. This figure drops to 69% for the winter months when the goats frequent a wider variety of ecosites. In winter seven ecosites accounted for at least 3% of all goat records, while only three ecosites were similarly important in summer.

Although the proportion of all observations drops in SB1 from 54% in summer to 34% in winter, the use of SB4 remains essentially as high in winter (35%) as in summer (36%). Consequently, SB4 is the most important winter habitat. It is possible, since SB4 is characrerized by avalanch activity, that winters of high avalanche occurrence could increase mortality of Mountain goats.

Open forest, particularly open mixed coniferous forest, is the most important vegetation type to goats in the study area. Of all goat observations, 51% were in open forests, compared to 19% in shrubby vegetation, and 15% in

herbaceous vegetation.

In summer 68% of all observations were in open forest but this decreased to 19% in winter when shrubby slopes, particularly avalanche slopes, increased in importance (37% of all observations).

The low importance of closed forest (1% of all observations) and the decline in importance of open forest in winter may both be artifacts, to some extent, of low goat visibility in these habitats compared to more open areas.

2. Bighorn sheep

Of 189 sheep records, 126 (66%) were adult males and 60 (31%) were unclassified. The Mount Wilson area is only a part of this sheep population's range and sheep are difficult to spot from the Icefields Parkway. Many more sheep were seen on an aerial survey on 22 March, 1979 than on a road survey the following day, indicating the inadequacy of road surveys for sampling this population.

All sheep observations, with one exception, were on Mount Wilson south of Ramparts Creek. The exception was 3 unclassified sheep observed on 1 August, 1978 on Mount Saskatchewan. These sheep may have been from the Mount Wilson population or, possibly, from the Tangle Ridge/Wilcox Pass population and consequently were not included in the data on the Mount Wilson population.

a. Population and group size

The maximum number of sheep observed on any survey was 29 on 2 November 1979. This is the minimum population of sheep in the area (Table 4.7).

Eighty-five percent of the sheep sightings occurred during the winter months and only three adult females and no young or young of the year were seen. It is thus concluded that the area is primarily winter range for rams and that the size of this population is therefore considerably larger than indicated by our samples.

The mean herd size of sheep on Mount Wilson for the survey period was 5.18. Herd size increases from a summer mean of 3.11 to a winter mean of 6.87. Only 15% of all sheep observations occurred in the summer months indicating that the larger ram herds of winter disperse to other ranges during the summer.

b. Seasonal habitat use

In winter all Bighorn sheep observations were in the lower subalpine ecoregion. In summer, use of the lower subalpine dropped to 86% with the upper subalpine and montane receiving, respectively, 7% and 4% of observed use. Evidently as winter snows melt there is a slight upward and downward shift in sheep range use. Greater numbers of sheep were observed in a smaller area in winter.

Open avalanche slopes accounted for the majority of all sheep observations, with 75% of all sightings being on SB4, the major winter habitat type. In winter 89% of all sheep observations were on SB4 while in summer 72% were on SB1 and none on SB4.

Only two ecosites (SB4 and SB1) received more than 3% of all sheep use in winter, while 5 ecosites received more than 3% of all summer sheep use, indicating that sheep are confined here to a relatively narrow range of habitats in

Table 4.7. Monthly counts and sex ratios of bighorn sheep along the Mt. Wilson survey route.

	N	average #/survey	max. undupl. count	% of total = rams	mean group size
May	5	0.2	1	100	1.0
June	4	0.8	3	100	3.0
July	1	0	0	-	-
August	4	0.5	2	100	2.0
September	4	0.3	1	?	1.0
October	1	0	0	-	-
November	4	9.5	29	50-100*	19.0
December	1	0	0	-	-
January	3	9.3	20	85-100*	4.7
February	1	26.0	26	100	5.2
March	3	9.7	27	100	5.8
April	3	12.3	26	30-92*	7.4
May	5	3.2	13	38-100*	3.6
				Average	5.18

*Higher values are based on the assumption that unclassified sheep are rams

winter compared to summer.

Summer observations of sheep were primarily (72%) in open coniferous forest, while most winter observations (82%) were in herbaceous vegetation particularly steep grassy slopes.

4.2.2 KERKESLIN UNGULATE SURVEY

Introduction

Between 10 August 1979 and 28 September 1980 ungulates were censused along the Maligne Range from Signal Mountain to Windy Castle and on Mounts Hardisty and Kerkeslin (Table 4.8). Nineteen viewing stations were established along the Icefields Parkway (Table 4.8). A total of 45 surveys were conducted. This summary describes seasonal habitat selection, group size, herd productivity and mineral lick use on the Mount Kerkeslin part of the survey area. By comparing our data to park warden observations from 1952 to present, trends in the relative size and productivity of this herd are discussed. The results are also compared to those obtained from goat surveys conducted elsewhere in Alberta and British Columbia.

Slopes were scanned using 8X40 and 9X50 binoculars and a 20-45X variable spotting scope. Roadside and riverbank mineral licks adjacent to the highway were checked on each survey. Most surveys were in mid afternoon or early evening when light conditions were most favourable.

Table 4.8. Mount Kerkeslin ungulate survey route: road log.

Stop #:	*Distance from last stop:* kms.	*miles*	*Location:*
1			Miette River bridge, Hwy. 93
-	10	6	Whistler Campground turnoff
-	16	10	Wapiti Campground turnoff
2	19	12	Mount Tekarra sign
-	13	8	Marmot Basin turnoff
3	21	13	Just past hiking trail lot, left
-	34	21	Borrow-pit road/gate to right
4	14	9	100 m before second trail sign
-	39	24	Raft tour dock
5	13	8	
6	35	22	
-	11	7	Hardisty Creek
7	3	2	Athabasca Pass sign
8	19	12	Horseshoe Lake on left
9	.6	4	Parking lot left
-	1.6	10	Borrow pit road left
10	.3	2	Pond right
-	1.2	8	Athabasca Falls turnoff
11	1.2	8	Athabasca Falls warden station
12	27	17	Mount Kerkeslin Campground
13	2.3	14	Goat Viewpoint
14	1.6	10	
15	1.6	10	
-	.5	3	Picnic area right
-	2.9	18	Opening in forest right
16	1.9	12	Mount Christie signpost
17	1.0	6	Across gravel channel
-	.7	5	Ranger Creek bridge
-	3.1	20	Campground left
-	1.2	8	Buck lake/Osprey Lake turnoff
18	1.4	9	Bog on left
19	6	4	Sunwapta Bungalows

Goats were classified to age and sex when viewed from close range at the mineral licks. Determining the sex of goats at distances of greater than 1 km, especially in winter, was difficult and unreliable. Thus no attempt was made to classify goats at long distances.

Locations of each ungulate observation were referenced to the U.T.M. grid on 1:50,000 National Topographic Series maps, and habitat type defined on the basis of ecosite and vegetation.

A single aerial survey was flown on 25 March 1980 using a Bell 206B Jet Ranger helicopter. This survey took approximately 2 hours under poor viewing conditions (bright overcast).

Results and Discussion

1. Mountain Goats

a. Population size

The maximum count of goats on a single survey was 51 on 21 June 1979. This total included goats at the mineral licks adjacent the Icefields Parkway as well as on the slopes of Mount Kerkeslin. Maximum unduplicated count of unclassified adults was 41 on 21 June and of young of the year was 16 on 4 December, giving an estimated minimum population of 57.

b. Population Trends

Since goats are commonly seen at the roadside and riverside mineral licks below Mount Kerkeslin, numerous warden observations of goats at these licks are on file. An assessment of trends in population size can be obtained by comparing maximum counts of goats at the licks since 1952 (park wildlife cards). Assuming that goats from the same general population have historically visited these licks, it appears the Mount Kerkeslin goat population has periodically fluctuated in numbers. In the early 1970's the maximum number of goats visiting the licks at a single sighting was 93, approximately four times the highest count during the present study (23).

It is probable that natural factors such as range conditions or winter severity are the major causes of population fluctuations in the study area. No major developed facilities or hiking trails are present other than the highway, which is not a major mortality factor (only 1 goat highway mortality has been recorded since 1952). The winter range is not used for cross-country skiing. Goats do not accept food handouts from tourists and are harassed by photographers only while visiting the mineral licks adjacent the highway.

c. Population structure and herd productivity

Productivity estimates from a number of studies in Alberta and B.C. have been expressed both as the number of kids per 100 adults and as the percentage of kids in the total population. The latter method is preferred due to the difficulty of separating yearlings from adults at long ranges.

Kids comprise 14.5% to 33.7% of the populations of six study areas in Alberta and B.C. In the Mount Kerkeslin population they comprise 19.4% of the total population, or 23 kids per 100 non-kids (Table 4.10).

Kids were most abundant in the survey area in November and December during which time they were moving onto winter ranges. The low ratio of kids to adults in summer suggests that nannies with kids do not use the visible parts of the range in summer.

d. Grouping Characteristics

Average winter (November to April) group size of goats in the study area was 5.4 while in summer (May to October) it was 3.7. These findings differ from those of Jacobsen and Loewen (1980) who noted that average group size in winter (2.6) was less than that in summer (5.2) in the Lake Louise area of Banff. In the Lake Louise study it was hypothesized that small, isolated pockets of winter range could not support large wintering herds.

On Mount Kerkeslin, in addition to numerous small pockets of habitat, there are two large wind-blown slopes of subalpine grassland totalling approximately 4 ha. Most goats congregated on these slopes, especially following heavy snowfalls. Consequently, average group size of this population is high during winter when compared to the Lake Louise study.

Table 4.10. Monthly counts and age/sex ratios of mountain goats along the Mt. Kerkeslin survey route.

	# of surveys	average # /survey	max. undupl. count	Young/ 100non-young	mean group size
October	4	23	33	22	3.5
November	7	27	48	32	3.6
December	4	34	45	30	9.6
January	2	32	32	40 (YLY)	7.9
February	3	28	34	25 (YLY)	5.6
March	3	13	26	21 (YLY)	4.0
April	4	14	22	50 (YLY)	4.5
May	2	28	34	4 (YLY)	3.3
June	4	32	51	12 (YLY)	5.3
July	3	10	24	24	5.0
August	4	10	38	25	5.7
September	4	19	38	23	2.9
Annual averages				23	4.5

Group size is low during September to November (Table 4.10). Following the first heavy snowfall goats congregated on the two extensive wind-blown slopes as indicated by the large December group size. Group size remained large throughout the winter until May when it dropped to 3.3, presumably as a result of pregnant females individually moving to kidding areas. Herds of variable size visited the mineral licks in summer. These were mostly nannies and kids. Nannies with kids were rarely seen on the slopes of Mount Kerkeslin in summer.

e. Seasonal habitat use

Goats were recorded on 11 ecosites during the course of the survey (Table 4.11). Goats were not equally detectable on all ecosites.

WF7, an upper subalpine colluvial ecosite characterized by grassland vegetation, was used heavily at all times of the year except during July. Heavy use of the ecosite by goats was also observed along the Palliser Range in Banff (see below).

SB1, a lower subalpine colluvial ecosite usually characterized by Engelmann spruce-subalpine fir forest with shrubby avalanche paths, received high use also. Goats were consistently seen here in autumn and winter.

WF3 is a rugged upper subalpine colluvial ecosite characterized by open coniferous forest. This habitat was used mostly between early September and late November by single goats or small groups. Most goats observed here were bedded or travelling to feeding areas.

NY3, a montane ecosite characterized by steep, gullied glacial till slopes with coniferous forest and grassland, received heavy summer use but this was due to the presence of the mineral licks discussed below.

Table 4.11. Observations of mountain goats on ecosites along the Kerkeslin survey route.

Ecosites	WF7	SB1	WF3	NY3	SB4	PR2	RO	SB3	MC2	EN3	WF2
January	18	16	13		15			1			
February	43	23			1		4	12	1		
March	24							4			
April	34	14	2		2			3			
May	15	16	6	17	1				1		
June	26	20	4	25	6	42	2		2	2	
July	5		1	24	1						
August	37		1		1		1				
September	17	22	18	5	6		8				
October	21	25	36		3		3	12	3		1
November	106	4	26		17	7	23	1	4		
December	114	16			2			3			
Survey totals:	460	156	107	71	55	49	41	36	11	2	1
%	46.5	15.8	10.8	7.2	5.6	5.0	4.1	3.6	1.1	0.2	0.1

WF4 is the most extensive ecosite along the survey route, covering much of the west side of Mount Kerkeslin. It is an upper subalpine colluvial habitat characterized by Engelmann spruce-subalpine fir forest on exposed bedrock. Goats used this habitat for bedding and travelling.

A single tract of SB3 with lush avalanche tracks through lodgepole pine-spruce forest on a steep rocky slope, occupies a small area near the Mount Christie viewpoint at the south end of the survey route. A band ranging in size from 3 to 15 goats used this tract regularly during the winter.

Rock and rubible were used only rarely, mostly in November. However, the likelihood of observers missing goats in this habitat was greatest since most use was by single animals that were at times hidden beneath rock outcrops or difficult to spot against broken snow cover.

Because very few kids were recorded during May and June, it is possible that females either gave birth in parts of their range not visible from the survey route, or hid beneath rock outcrops or in caves.

f. General Habitat Use

During the winter, most goats were observed on steeply sloping grassland/herb slopes of colluvial origin below rock and colluvial rubble escape terrain. Slopes were of south to west aspect. Goats most often assembled in herds of 16 to 23 animals on two ranges which are separated by three major drainage gullies and five kilometres. These two slopes are both steep aprons covered with herbaceous vegetation characterized by bearberry and hairy wildrye. It was not possible to determine whether goats moved between these two slopes during winter.

Another winter habitat which supported somewhat less goat use, mostly by single or small groups of two to four adult goats, were the upper reaches of

drainage basins. These basins contain small, isolated grasslands and considerable exposed bedrock.

Rock ledges, bedrock outcrops and talus slopes were used most often by single goats in late autumn just before the first major snowfall.

A wider range of habitat types was used by goats during summer, when goats travelled to the mineral licks adjacent to the Icefields Parkway and foraged in habitats unavailable in winter due to snow. The same habitats used commonly by large herds of goats during winter were used less frequently in summer by single animals or small groups. Goats were also seen on rock outcrops in closed forest five times. These sightings were near the the mineral licks, presumably of animals travelling to or from the licks. Lower overall counts during the summer months are possibly a result of our not being able to see goats travelling in forest cover between the mineral licks and the open slopes. Possibly some goats moved onto summer ranges remote from the highway.

Goats were observed most often on grassland/herb meadows. Shrub cover is very limited on Mount Kerkeslin. Goats did not use avalanche tracks extensively in winter or summer.

g. Mineral Lick Use

Goats were seen at mineral licks on eight occasions from 14 May 1980 to 28 September 1980. Two licks within 100 m of one another were used, one on the shoulder of Highway 93 and the other on the east bank of the Athabasca River. The latter lick is of natural origin, the former a result of highway construction. A visitor viewing area is located directly above the riverbank lick while a pull-off point is located opposite the roadside lick.

The maximum number of goats at the mineral licks was 23 on 7 July. There were 32 goats on a rock outcrop in closed forest approximately 400 m from the lick on 15 June.

McCrory (1965) found that peak use of the "Athabasca Falls" lick was in late June (Figure 3.53). Jacobsen and Loewen (1980) found that peak use of a mineral lick on the west slope of Lipalion Mountain in Banff was from June until early August. Our data indicate maximum use during June; goats were seen at the mineral licks on each of four surveys conducted during this month.

Goats were not seen at either lick during the winter. Park warden H. Elvin reported a small herd of goats using the Mount Kerkeslin lick in late February of 1969. This is the only evidence of winter lick use by goats in the Athabasca district since 1944. From warden observations, the earliest spring and latest autumn use of the Mount Kerkeslin licks are 21 April and 14 October.

Goats were seen using the licks from as early as 10:00 a.m. to as late as 6:30 p.m. McCrory (1965) found that most sheep and goats arrived at the Shalebanks lick in east-central Jasper National Park between 10:00 a.m. and 3:00 p.m. (MST). He related this to diurnal feeding activity. It was assumed that goats and sheep left for the lick after morning feeding periods and arrived at the licks near midday.

No evidence of predation was seen at the mineral licks. There is a single record of an unsuccessful attempt by a coyote at the Mount Kerkeslin lick in 1965. At the Shalebanks lick, black bears were the most frequently observed potential predator (McCrory 1965). Grizzly bears, wolves, cougar, lynx, coyote, fox and bald eagle were also noted at this lick.

Park warden reports from the Athabasca district include two records of unnatural mortality at the Mount Kerkeslin goat lick. A kid was killed in a collision with a vehicle in October 1966. A female died after eating a plastic bag on 11 July 1970. Park visitors do not feed goats at these mineral licks. Female goats with young threatened photographers on two occasions when approached too closely.

4.2.3 CASCADE FIRE ROAD UNGULATE SURVEY

Introduction

A regular roadside ungulate survey was conducted along 55.1 km of the Cascade Fire Road in Banff from the Cascade River bridge to the Red Deer River valley, from 31 May 1979 to 29 November 1979. In addition to 22 roadside surveys, one summer and four winter aerial surveys and one ski census were conducted along portions of the survey route.

A total of 48 stops were established along the fire road (Table 4.12). All slopes were scanned from each stop with binoculars and a 20-45X variable spotting scope. Elevation, U.T.M. grid reference and habitat, based on ecosite and vegetation type, were recorded for each ungulate or group of ungulates sighted. Age and sex were determined whenever possible.

The duration of surveys averaged 4 hours with most surveys conducted from mid-morning to mid-afternoon.

This report summarizes and discusses the seasonal and geographic distribution and abundance of ungulates along mountain ranges adjacent the Cascade fire road, with reference to age/sex classes of ungulates and the relative importance of habitat types and mountain ranges. Most complete data were obtained for bighorn sheep and elk, thus these two species are dealt with in greatest detail. Mountain goat, mule deer, and moose sightings are discussed in less detail.

Results and Discussion

1. Elk

a. Overall and Seasonal Abundance

A total of 1456 elk were observed in 153 independent sightings, yielding an average of 9.5 elk per sighting and 54.3 per survey (Table 4.13). The highest single survey count was 163 on 29 November. Most elk were observed in November when mixed age/sex herds of elk congregated along open slopes, particularly along the Palliser Range. Average group size was also greatest during this month (Table 4.13).

Lowest numbers of elk were observed during the rut, which, based on bugling records, extended from the first week in September to early October. Elk were more confined to forested habitat during the rut.

Low mid-summer counts suggest that most herds may have summered in areas other than the survey route.

Table 4.12. Cascade Fire Road ungulate survey route: road log.

Stop #:	*Distance from last stop: kms.*	*miles*	*Location:*
1			Cascade River bridge
2	0.5	0.3	
3	1.4	0.9	
4	2.0	1.3	
5	0.6	0.4	
6	1.2	0.6	
7	1.2	0.6	Stoney Creek warden cabin
8	1.5	0.9	Stoney Creek bridge
9	1.4	0.8	
10	0.9	0.5	
11	0.5	0.3	
12	1.1	0.6	
13	1.0	0.5	Elk trap access road
14	0.7	0.4	
15	0.7	0.4	
16	1.6	1.1	
17	0.8	0.5	
18	0.4	0.2	Flint's Park road bridge
19	0.8	0.5	
20	2.3	1.3	Old warden school
21	0.5	0.3	
22	1.9	1.2	
23	0.4	0.2	Cuthead Creek bridge
24	1.2	0.6	
25	0.9	0.6	
26	0.6	0.4	
27	1.0	0.5	
28	0.9	0.5	South end of Wigmore Lake
29	0.4	0.2	
30	0.9	0.5	
31	1.7	1.0	
32	0.1	0.1	Wigmore Creek bridge
33	0.8	0.5	Windy warden cabin access road
34	1.7	1.0	
35	0.4	0.2	
36	1.5	0.9	Harrison Lake sign
37	0.9	0.5	
38	0.8	0.5	
39	0.8	0.5	
40	0.8	0.5	Grouse Lake sign
41	0.8	0.5	
42	0.7	0.4	
43	0.8	0.5	
44	0.8	0.5	
45	1.2	0.6	Snowflake Lake sign
46	0.3	0.2	
47	1.5	0.9	
48	1.5	0.9	

Table 4.13. Monthly counts and age/sex ratios of elk along the Cascade Fire Road survey route.

	N	average #/survey	max. undupl. count	Young/ 100 females	mean group size
June	3	75	105	8	6.1
July	4	42	85	17	12.1
August	4	58	95	6	10.0
September	5	27	60	16	4.1
October	6	34	92	7	6.7
November	4	123	163	22	32.7
Overall averages				12.8	9.6

Cow/calf herds were seen most often during November. As a result of their increased visibility at this time the calf/cow ratio was highest during this month (Table 4.13).

Adult males were most observable in September, and, to a lesser extent, in October. Observations of males that were not seen but were heard bugling in heavy forests contributed to the high percentage of males counted during the rut. The proportion of males to other age/sex groups was very low during November (Table 4.13). This may be due to the continued use of forest after the rut, to the arrival or increased visibility of cow/calf groups, or to movement of bulls to isolated winter ranges.

b. Monthly Geographic Distribution

End of May/June

Most elk were along the Palliser Range and first Grassy Mountain. On all 4 surveys in this period elk were seen in birch-willow shrubland along the Cascade River adjacent the Palliser Range. This included a cow/calf herd of 30 animals. Elk were seen only sporadically in this habitat throughout the remainder of the survey.

Another cow/calf group of 52 animals was seen on open slopes 3 km north of Cuthead Warden cabin. This may be a subgroup of the herd of 114 elk seen by Hamer (pers. comm.) above Cuthead Lake on 31 July, 1979.

July

All four surveys conducted during this month were on hot, sunny days. Elk observations were rare with most elk being sighted at high elevations on ridge crests. A cow/calf group of 13 elk and two solitary cows were seen near the elk trap at the north end of the Palliser Range.

A mixed herd of 62 elk was first sighted in early July in a basin two kms northeast of Harrison Lake. The herd remained in this general area until the third week in September. No bugling or rutting behavior was observed here. This elk herd is probably the "Harrison Lake Herd" mentioned by Morgantini (1978). He estimated the herd's size as 70 during the summer of 1978.

August

In addition to the large herd in the Harrison Lake area, solitary bull elk were sighted on three occasions feeding along avalanche slopes near Snow Creek Summit.

A herd of 19 females, seven yearling males, and two calves was also seen in the Mount White area south of Scotch Camp meadows in late August. These animals probably belonged to the Mount White group referred to by Morgantini (1978).

In the last two weeks of August scattered individual female elk were seen at timberline at the southern extremity of the Palliser Range.

September

Almost all the elk we observed in September were along the south end of the Palliser Range. Rutting elk were concentrated roughly within 2 km of the Stoney Creek bridge. Bugling was first heard on 2 September and was concentrated in open mixed conifer/poplar forest just below treeline on the Palliser Range as well as in lodgepole pine-spruce forest and avalanche tracks on the west side of the Cascade River. Bulls were also heard bugling on the avalanche slopes west of Stoney Creek Warden cabin. Struhsaker (1967) found the peak rutting period of elk on the Palliser Range to be 8 to 21 September.

October

Bugling was last heard at the south end of the Palliser Range on 6 October. The number of elk sightings decreased in this area as the month progressed. Two lone bulls and a bull with seven cows remained here until the end of October.

Across the Cascade River on the open slopes north of Stoney Creek Cabin, a herd of 45, including six bulls, was seen first on 24 October. This group was seen again on the same slope on 14 November. Elk winter in the Elk Creek valley southwest of these slopes. Up to 88 elk have been seen in that vicinity (Warden record: 26 December 1970). It is possible that the aforementioned herd of 45 wintered in this area.

November

Throughout November post-rut congregations remained on the Palliser Range. By 29 November 149 elk had moved onto the Palliser Range in the area around the elk trap. These groups included all age and sex classes. No elk were observed route north of the Flints Park turnoff.

c. Herd Productivity

A ratio of 12.8 calves per 100 cows was calculated over the six month sampling period (Table 4.13). Morgantini (his Table 4) determined calf/cow ratios for the years 1977-79 of an elk population which summers in the Red Deer River valley of Banff National Park and winters on the adjacent Ya-ha Tinda Ranch. He noted a steady decline in productivity from 31 calves/100 cows in September 1977 to 27 calves/100 cows in September 1978. Our data show a ratio of 20 calves/100 cows along the Cascade fire road survey route in September 1979.

A roadside survey of the lower Athabasca Valley of Jasper National Park yielded an average ratio of 24.3 calves per 100 cows over the period June 1978 to February 1979 (see above). Holroyd (1976) calculated ratios of 54.0

(October) and 76.9 (November) calves per 100 cows along the Trans-Canada Highway in the Bow valley. Cow/calf ratios in the Cascade River valley have consistently been lower than elsewhere in Banff since 1976.

The low productivity of Cascade valley elk combined with decreasing productivity of the nearby Banff/Ya-ha Tinda herd (Morgantini 1979), suggest that elk herds along the east slope of Banff National Park may be stable populations subject to low mortality (Geist 1971). If these herds sustain high mortality they may be in decline.

Low herd productivity as revealed by low calf/cow ratios, may be due to factors other than population decline or stability. Yearling females can often be mistaken for adult females at even moderate distances or in poor light conditions. This source of error would be most serious, in terms of altering calf/cow ratios, following a productive calf crop and/or high calf survival the year before a survey. Morgantini's data, however, do not indicate an exceptional calf crop in the summer of 1978. Our data are not complete enough to assess calf survival over the winter of 1978/79 but there is no reason to suspect that their survival was exceptionally high.

The low calf/cow ratio observed in the Cascade Valley area may also be a result of deterioration of winter range, disease, or high post-natal mortality. Stephen Herrero (pers. comm.) has found evidence of predation on newly-born calves by grizzlies.

d. Elk/Habitat Relationships

Elk were noted in a much greater variety of ecosites than other ungulates. Grassland-dominated upper and lower subalpine ecosites of colluvial origin (eg. WF7, SB5, WH4) yielded the greatest percentage of overall elk sightings (Table 4.14). Elk were seen in this habitat even in mid-day during the hot summer months when other ungulates were rarely observed.

Shrubby habitats typical of such ecosites as HC4, TR1, and SX3 were used predominantly in the month of June. GT2, a lower subalpine glacial till slope with mixed open conifer/poplar forest along the base of the Palliser Range, received heavy use during the rut.

Most elk sightings (59%) were in the upper subalpine ecoregion (Table 4.15). Lower subalpine sightings made up 31% of all elk sightings while alpine habitat received relatively low use at 10%. Montane habitat was only represented along the first mile of the survey route. Elk were sighted in alpine areas most often in July and August.

2. Bighorn Sheep

a. Overall and Seasonal Abundance

Over the survey period (May to November) 1171 sheep were observed in 202 independent sightings or an average of 5.8 sheep per sighting and 53.2 per survey.

The largest number of sheep observed in a single survey (160) was on 6 November (Table 4.16). Most of these sheep were on the Palliser Range. Sheep counts were highest from the last week in October to the first week of November. Average group size was highest in November (pre-rut period) when ewes and rams were closely associated.

Table 4.14. Observations of elk on ecosites along the Cascade Fire Road survey route.

Ecosites	WF7	SB5	WH4	GT2	TR2	RD1	HC4	KA1	TR1	PP6	WF4	PR2	JN1	SX3
June	45	6	4	73	2		35		13	2	1	2		15
July	58		62			8	2	38			9			
August	64	36	53	8	20	31							15	
September	9		31	16	3	6	1			2		6		
October	123	3	2	8	37		1		5	8		21		
November	100	168		19										
Survey totals:	399	213	152	124	62	45	39	38	18	12	10	29	15	15
%:	32.9	17.6	12.5	10.2	5.1	3.7	3.2	3.2	1.5	1.0	0.8	2.4	1.2	1.2

No major sheep herd summered within view of the Cascade fire road, hence, counts during July and August were very low and consisted mainly of isolated rams or small ram groups.

Nursery groups were not commonly observed until October and November. The high percentage of rams making up the total sightings in June and July (Table 4.16) reflect the scarcity of ewes and lambs during these months.

Three aerial surveys were flown along the Palliser Range and Grassy Mountain in late winter 1980. The results of these surveys are compared to warden winter helicopter surveys of 1975 and 1976, and 1965 population estimates from Geist (1971) (Table 4.17). Geist's figures are based on roadside surveys which tend to produce higher counts because of the longer viewing periods. In addition, there is interchange of sheep between the Palliser Range and the Cascade Range, where 35 sheep were counted during the 26 February survey. It is probable that sheep regularly cross the Cascade valley during the winter (Geist 1971).Two rams crossed from Palliser Range to the Cascade range through 65 cm of snow on 7 January 1976 (KVT).

In late winter more sheep are on Grassy Mountain than on the Palliser Range.

b. Monthly Geographic Distribution

End of May/June

Solitary rams and scattered herds of from 2–10 rams were seen along the length of the Palliser Range especially in late May and early June. A small nursery group was seen on the Bare Range just north of Windy Cabin. A group of four rams was observed on an open slope on the Cascade Range.

July

Sheep were almost entirely absent along the visible portions of the survey route in July. The only sheep observed were four mature rams in timber near the Windy Warden cabin on the Panther River. Geist noted a similar desertion of the Palliser Range during the summer months. There is a summer sheep concentration in the Dormer Summit area (Warden files). These sheep are

Table 4.15. Relative distribution of ungulate observations along the Cascade Fire road survey route, by ecoregion

	Sheep		Elk		Goat	
	#	%	#	%	#	%
Alpine	83	7.4	98	8.1	1	3.1
Upper subalpine	897	79.9	707	58.3	28	87.5
Lower subalpine	142	12.7	408	33.6	3	9.4
Montane	–	–	–	–	–	–
Totals:	1,122		1,213		32	

possibly the same ones that winter on the Palliser Range.

August

Sheep continued to be uncommon along the survey route throughout August. Three small ram groups were seen on the Palliser Range. Three rams were seen on two occasions at Snow Creek summit, bedded on talus slopes at mid-day.

September

Sheep sightings increased in September especially on the Palliser Range. Herds of up to 11 rams were seen regularly on the ridges comprising the northern third of the Palliser Range. Sheep were very rarely seen at the south end of the Palliser Range in September. At this time elk used this area as a rutting range. Ewe groups were not yet present on the Palliser Range. A nursery group of seven females and four lambs on the slope immediately south of the Windy Warden cabin was the largest ewe group seen in September.

October

The first of the large ewe groups appeared on the Palliser Range in early October. Ewe groups occupied the middle and southern slopes of the Palliser Range during October, separate from the ram herds which continued to build up at the north end. Of 27 independent sightings of ewes or nursery groups, 19 were not associated with mature rams. By comparison, in the month of November only five of 41 ewe groups were not with rams.

Elsewhere, up to 14 adult rams resided most of October on the first open slope of the Cascade Range north of Stoney Creek. The first sheep on Grassy Mountain were seen on 30 October. Other than three ewes sighted on Cascade Mountain, and 10 rams on the Bare Range one mile north of the Panther River, all October sheep observations were in the vicinity of the Palliser Range.

November

In November, rams and ewes mingled freely on the Palliser Range and Grassy Mountain, the two traditional wintering areas described by Geist. These two areas received the bulk of use by sheep seen along the survey route. Four groups of sheep were also seen on slopes of the Cascade Range opposite the Palliser Range. The largest of these consisted of nine rams, four ewes, three lambs and six unclassified. The remaining observations were of small ram groups

Table 4.16. Monthly counts and age/sex ratios of bighorn sheep along the Cascade Fire Road survey route.

	# of surveys	average # per survey	max'm count	YOY/ 100 females	YLY/ 100 females	%=adult rams
June	3	22	29	50	–	68.2
July	4	1	4	–	–	100.0
August	4	10	16	–	22	16.7
September	5	22	37	19.4	11	20.2
October	6	93	155	9.5	4	34.9
November	4	91	160	21.8	–	35.4
Average				15.9	3.8	32.0

numbering two to five animals. Only once were 16 sheep seen on the Bare Range, east of Snow Creek summit.

Sheep were concentrated at the south end of the Palliser Range. A lesser amount of activity was observed along the northern third of the range, while the middle portion was apparently not used.

c. Lamb Production

Over the six month survey period (May to November) the cumulative count was 367 ewes and 69 lambs yielding a ratio of 18.8 lambs per 100 ewes. Geist (1971) reported lower late summer and fall lamb/ewe ratios of 15.5 and 18.0 lambs per 100 ewes.

Lamb/ewe ratios from data collected by Tithrington (from Geist 1971) at Aylmer Mountain in Banff National Park ranged from 48.5 to 87.0 lambs per 100 ewes. These figures were obtained from data collected solely at a lick and as such may be biased, assuming that ewes with lambs may be drawn to salt licks to a greater degree than barren ewes because of the demands of parturition on body salt. The ratios are much higher than ratios from the Palliser Range.

During the lower Athabasca valley ungulate survey (below) a ratio of 34.6 lambs per 100 ewes was obtained from May to November. From aerial surveys conducted from November to January 1966–71 average ratios of 51.6 and 44.6 lambs per 100 ewes were calculated in Banff and Jasper National Parks (Stelfox, 1976).

It is apparent that lamb/ewe ratios are lower than average in the Front Ranges along the Cascade fire road.

d. Seasonal Habitat Use

Bighorn sheep used upper subalpine grasslands more frequently than elk, particularly the WF7 ecosite (Table 4.15, 4.18). During the hot summer months most sheep were seen at high elevations in talus or colluvial rubble. Sheep were very rarely seen in forested habitat. Of forested ecosites in which sheep were seen, GT2, WF3, TR1 and WF2 support Engelmann spruce–subalpine fir open forest while SF1 and PL1 are predominantly Engelmann spruce–subalpine fir closed forest. Most alpine sightings were on the Bare Range where alpine habitat

Table 4.17. Counts of bighorn sheep wintering on the Palliser Range and Grassy Mountain, Banff National Park.

Date	Palliser Range	Grassy Mtn.	total	Source
Feb. 1965	60	59	119	Geist (1971 Figs 8.9)
25 Feb. 1975	15	61	76	Warden survey
21 Apr. 1975	–	57	57	Warden survey
30 Dec. 1976	34	47	81	Warden survey
23 Feb. 1980	32	61	93	this survey
26 Feb. 1980	27	41	68	this survey
27 Mar. 1980	23	35	58	this survey

is more visible from the fire road.

Sheep used fewer ecosites than elk in proportion to the number of sightings.

3. Mountain Goat

A total of 82 mountain goats were observed in 34 sightings or 2.4 goats per sighting and 3.8 goats per survey. Mountain goat concentrations were consistent in only three areas along the survey route. Scattered observations were made in a few other areas. Of these 34 sightings, 23 were along the Palliser Range from Stoney Creek to a point opposite first Grassy Mountain. The maximum single day count of goats on the Palliser Range was six on two occasions. In the past, up to 11 goats have been reported by wardens on the Palliser Range (16 May 1955). Another major concentration of goats was observed from late summer to fall on northeast-facing slopes of Cascade Mountain between the Cascade River bridge and the Stoney Creek cabin. A maximum of 14 goats was observed in this area on 6 September.

The only other goat herd of significant size was on the Bare Range immediately south of the Windy cabin. Seven goats were present.

Based on maximum counts of distinct herds and scattered individuals a minimum number of goat along the survey route is 32.

Autumn, particularly September, proved to be the best time to survey goats. Goats were rarely observed during the hot months of June, July and August (Table 4.19). Shank (1978) observed goats along the Palliser Range most frequently in October and November. He found that mid-winter sightings were uncommon and that goats were seen more often beginning in March.

Goats were observed in only four ecosites, excluding rock and colluvial rubble (Table 4.20). Most detected use occurred in the upper subalpine and alpine. Of the 34 sightings 16 were on the WF7 ecosite. The upper portions of these grassland-dominated colluvial slopes with exposed bedrock are highly preferred by goats especially on the Palliser Range. A similar preference has been noted on Mount Kerkeslin in Jasper National Park. Goats seen on northerly exposures of Cascade Mountain were often bedded on the upper portions of talus slopes.

Table 4.18. Observations of bighorn sheep on ecosites along the Cascade Fire Road survey road.

Ecosites	WF7	SB5	BS1	RO	GT2	RD1	CR	SF1	TR1	WF3	WF2	WH4	PL1
June	40	12			9					5			2
July					4								
August	7	9	10		2	4	7						
September	74	2	4		7	1						3	
October	479	50	24			6			10		3	2	
November	259	47	34	5			4	13					
Survey total:	859	120	72	5	22	11	11	13	10	5	3	5	2
%:	75	11	6	–	2	1	1	1	1	–	–	–	–

4. Mule Deer

Mule deer were rarely sighted in the survey area. Hence, there are insufficient data to calculate age/sex ratios for this species. Nine sightings were made totalling 17 animals, all females. All observations were from late August to mid October.

From the limited data there appear to be two areas of mule deer concentration. One lies near the confluence of Snow Creek and the Panther River while the other appears to be along the Palliser Range to near Grassy Mountain in the vicinity of the Cuthead warden cabin.

Mule deer were seen in the following ecosites; HC4(X2), BK4, PR2, SB5, GT2 and PP7. All but one of these ecosites are in the lower subalpine ecoregion.

Mule deer prefer low elevations in Banff and Jasper National Parks. This, along with a predilection for forest cover, may explain the limited number of deer sightings along the survey route, which includes little montane habitat.

5. Moose

In spite of an abundance of shrubby alluvial areas and avalanche slopes, moose were uncommon along the survey route; only two were sighted. One female was seen at Wigmore Lake. The other, a yearling male, was seen feeding on submergent vegetation 2 km south of the Cascade River bridge.

Table 4.19. Monthly counts of mountain goats by age/sex class along the Cascade fire road survey route.

	# of surveys	mean # goats per survey	max'm count	UNCL.	F	YOY	YLY
June	3	3.0	6	7	1	1	1
July	4	-	-	-	-	-	-
August	4	0.5	1	2	-	-	-
September	5	5.6	14	18	4	4	2
October	6	4.3	11	12	2	3	9
November	4	4.7	10	17	-	2	-

4.2.4. LOWER ATHABASCA SURVEY

Introduction

A regular roadside visual census of sheep ranges along the lower Athabasca valley was conducted from 2 June 1978 to 4 April 1979. Surveys were conducted at least five times monthly and lasted an average of two hours. The survey route transected the northern ends of the Colin, Jacques and Miette Ranges. Regular stops were made at locations listed on a roadlog (Table 4.21) and all slopes were thoroughly surveyed by binoculars and 20-45x variable spotting scope. All ungulates seen were counted and classified, when possible, as to age and sex.

Surveys were conducted at various times of day but most frequently during early afternoon (1300 -1700 hrs). This time was chosen because lighting and daily activity patterns of sheep provided generally optimal visibility at this time. However, elk and deer activity is generally low at this time. Consequently not enough observations of these species were recorded to provide sound information on seasonal range selection. Consequently, except for calculations of age/sex ratios, the discussion which follows deals only with bighorn sheep.

Results and Discussion

1. Elk

Elk counts were too low in most months to provide sufficient data for age/sex ratios. By the end of February the cumulative count stood at 82 cows, 20 calves, 73 bulls and 228 unclassified. This yields approximate ratios of 24.3 calves per hundred cows, and 89.0 bulls per hundred cows.

2. Sheep

Counts were consistently low during June, July and August. A gradual increase of sheep on winter ranges along the lower Athabasca valley began in early September and peaked in November, December, January and February, followed by a gradual decline until April. Maximum single-survey counts were 110 on November 22; 168 on January 14; and 100 on February 17.

Total population of the survey area was around 250 animals (based on maximum single counts on each of the three major mountain ranges along the survey route). Minimum total population of the survey area was 168 (based on maximum single-survey

Table 4.20. Observations of mountain goats on ecosites along the Cascade survey route.

Ecosites	WF7	RO	CR	WF2	SB5	HE1
June	3					
July						
August	1		1			
September			14	2	3	1
October	17		7	2		
November	3	16				
Survey totals:	24	16	22	4	3	1
%	38.6	22.9	31.4	5.7	4.3	1.4

count).

For purposes of discussion and because their seasonal movements were found to differ, rams are discussed separately from ewes, lambs and yearlings.

a. Rams

Very few mature rams were observed along the survey route during the summer. One band of 25 rams was observed on 2 June at the Cold Sulphur Springs pull-off where they were no doubt using a mineral lick. They were not observed again on subsequent surveys.

Rams began to increase in number along the survey route in mid-September, somewhat later than ewe herds. By early April rams had mostly disappeared from the survey route (Table 4.22).

Highest numbers were consistently recorded on the Jacques Range (maximum 27) and, secondarily, the Miette Range (maximum 25). This may in part be a sampling artifact; visibility of sheep is lower on the Miette and Colin Ranges and there is greater likelihood of observers missing bands that are present. Patchiness and absence of snow over most of the 1978/79 winter further confounded attempts to obtain accurate counts.

Highest ram counts were during the month of November and again in late December and early January. Most rutting activity was observed during the last three quarters of November and early December. Some activity was noted as late as 21 December.

Rams appear to move from one mountain range to another over the year. For example: Rams increased on the Jacques Range from 14 October to 4 November. A temporary drop on 9 November corresponded with a temporary peak on the Miette Range. Again, on December 10 a decline in the Jacques Range rams began and corresponded with an increase in rams on the Miette Range. A maximum of 26 rams were seen on the Miette Range on 15 December; on the 17th only two were seen there but 22 were on the Jacques Range. By the 21st there were none seen on the Miette Range and 27 on the Jacques Range. Thereafter until mid-February, a decline in the number of rams on the Jacques Range appears to correspond to an increase on the Colin Range. In March rams were rare on the Colin and Jacques Ranges but consistently

Table 4.21. Lower Athabasca ungulate survey route: road log.

Stop #:	*Distance from last stop: kms.*	*miles*	*Location:*
	0	0	North end of Jasper townsite
	2.7	1.7	Maligne rd./Hwy. 16 junction
1	12.0	7.5	Start. Snaring River bridge
2	1.8	1.1	
3	1.5	0.9	Mile 12 bridge on Athabasca River
	.3	0.2	North end of Mile 12 bridge (Morro Point)
4	.5	0.3	Cold Sulphur Springs parking area
5	.7	0.4	Mile 18
6	.7	0.4	North end of Mile 18 pond
7	.8	0.5	'Mushroom Patch' area
8	1.4	0.9	Base of Jacques Range
9	1.6	1.0	Viewing location for Cinquefoil Ridge
10	.8	0.5	Viewing location for Cinquefoil Ridge
11	.8	0.5	Viewing location for Cinquefoil Ridge
12	4.5	2.8	'Big Bend' adjacent Talbot Lake
13	1.9	1.2	Rocky River bridge
14	1.9	1.2	Viewing location for Miette Range
15	1.0	0.6	Disaster Point
16	.6	0.4	Viewing location for Miette Range
17	.2	0.1	Lime kiln mineral lick
18	.8	0.5	Viewing location for Miette Range
19	2.7	1.7	Pocahontas Pond
20	.8	0.5	End. Pocahontas Warden Station

present on the Miette Range.

These variations could be coincidental in that each range has different habitat characteristics and when rams are on visible portions of one range they may be on remote portions of another. Moreover, access from one range to another, especially in winter, is difficult. This applies in particular to the Miette and Jacques Ranges. A maximum count of 39 rams on all ranges on January 14 indicates that many rams were not accounted for during the rest of the winter and probably occupied more remote portions of each range.

Nonetheless, there is enough evidence to imply that rams may be moving along the Athabasca valley from one range to another far more regularly than is presently believed. If this is the case, our present estimates of sheep populations may be significantly incorrect. This hypothesis might best be tested by marking a number of sheep and monitoring their movements throughout ensuing seasons.

b. Ewe, Yearling and Lamb groups

Ewe groups were rarely seen along the survey route during the summer. Bands were seen most commonly near the Cold Sulphur Springs, Mile 18, and the old lime kiln at Disaster Point, where they use mineral licks. Our surveys did not reveal any periods of heavy lick use, but surveys were not conducted in May.

Table 4.22. Monthly counts and age/sex ratios of bighorn sheep along the lower Athabasca survey route.

	# of surveys	mean # sheep per survey	max'm count	YOY/ 100 females	YLY/ 100 females	% = ad. rams
June	6	8.2	44	26.6	–	42.9
July	5	8.4	32	54.1	12.5	0
August	6	7.0	27	–	–	0
September	8	29.0	73	36.7	15.6	6.0
October	4	64.8	80	26.0	19.1	7.7
November	7	58.6	110	32.9	20.5	24.6
December	8	51.0	93	38.1	23.1	22.8
January	6	64.8	168	24.7	17.2	14.7
February	7	43.6	100	33.3	14.5	14.1
March	7	36.1	57	20.3	16.3	11.5
April	1	27.0	27	–	–	14.8
May	1	19.0	19	–	–	0
Averages:		37.3		31.5	17.8	6.0

– = Insufficient data
0 = None

Numbers began to build up on the winter ranges in early September. Sheep increased first on the Colin range but by early October few were seen there and numbers had begun to increase on the Jacques and Miette Ranges. As was the case with rams, maximum concentrations were recorded in November (22 November: 99 animals) and again in late December and early January (17 and 21 December, 14 January: 68, 66, 118 animals respectively). The largest band, averaging about 90 animals at midwinter, ranged between Cinquefoil Ridge (at the south end of Talbot Lake) and the open slopes of the Jacques Range 2 km. south. Maximum numbers did not occur simultaneously on all ranges along the survey route; however, there was less indication of movement from one range to another than was evident from statistics for rams.

Sheep had virtually disappeared from visible portions of the Colin and Jacques Ranges by the end of February, but were still common (10 to 45 animals) on the Miette Range until early April. Most observations of rutting activity and sheep during the rut (November and December) were on the Jacques Range and, to a lesser degree, the Miette Range. There are no important rutting areas on the part of the Colin Range that we surveyed, and we believe that most of the sheep using the Colin Range either joined the larger Jacques Range herd or rutted at the south end of the Colin Range near Maligne Canyon, an area that was not included in our survey.

Productivity

During the survey period the mean lamb/ewe ratio was 32/100 and the mean yearling/ewe ratio was 18/100. The greatest lamb/ewe ratio (54/100) was recorded in July, when nursery bands were frequenting mineral licks while barren ewes remained on summer ranges. The actual number of lambs to ewes is probably somewhat higher than that recorded, since lambs are occasionally missed

Table 4.23. Observations of bighorn sheep on ecosites along the lower Athabasca survey route.

Ecosites	CR	DV1	HD2	NY3	PR2	PT3	RO	SB4	TA2	TA3	VL1	VL3	VL5
June						39			9		42		
July									29		6		
August								74	84		29		23
September	12				2				210		8	24	
October		35		4				12	294	14	11	3	2
November	10		36				2	36	327	1	4	7	
December		10						50	148	18	122	14	
January	15							16	132		68	3	6
February		31				10		11	111			122	
March									20			5	
April													
Survey Totals	37	76	56	4	2	49	2	199	1,364	33	290	178	31
%	1.6	3.3	1.6	0.2	0.1	2.1	0.1	8.6	59.2	1.4	12.6	7.7	1.3

when bedded down separately from their feeding mothers, and since barren ewes may be generally more visible than nursery groups. The ratio of lambs to 100 ewes in December was 38.1; this figure should serve as a basis for comparison against future classified counts.

Habitat use

Highest numbers of sheep were counted on the TA2 ecosite, especially from August to February (Table 4.23). The windblown, grassy slopes characteristic of this ecosite provide excellent winter range. SB4, a lower subalpine ecosite characterized by steep colluvial grasslands that are frequently bared by wind, was also consistently used. There are few extensive tracts of SB4 visible from the highway. The VL1 and VL3 ecosites received heavy use too, although sheep only foraged on tracts adjacent to rocky mountain spurs and mineral licks. These alluvial ecosites are seldom important to sheep except where they are adjacent to escape terrain.

There were very few sheep observed on montane ecosites along the survey route in summer (Table 4.23).

Monitoring of sheep population in the lower Athabasca River valley can best be achieved by conducting classified counts of herds on the three main mountain ranges six to eight times during late December and early January when the animals are at maximum concentrations on their winter ranges. Ewes and yearlings should be separated wherever possible and where uncertainty exists they should be listed as unclassified. Males should be classified according to quarters of horn curl Geist (1971). Unclassified males should be listed separately from other unclassified animals.

Before reasonable estimates can be made concerning total populations of sheep along the lower Athabasca valley, the degree of migration from one range to another must be ascertained. This would best be achieved by visibly marking a number of sheep of each age/sex class and periodically monitoring their locations.

5. SPECIES ASSEMBLAGES

5.1. BREEDING BIRD COMMUNITIES

An important goal of the wildlife inventory is to determine which habitats in the national parks are most valuable to wildlife. Since every habitat may be important for at least one species, some way had to be found to group species and distinguish habitats. Intuitively it is obvious that some habitats are more important for breeding birds than others. The following process was created to identify the more important habitats using defined criteria.

The basic unit of the land inventory is the ecosite, a concept comprised of landform, soils and vegetation (Volume II). Traditionally, breeding bird distribution has been associated with vegetation. Since each ecosite may include several vegetation types it was decided to use vegetation types as the basis of breeding bird habitat. This approach was facilitated by each bird transect being located in one vegetation type.

The analytic procedure we used first calculated the density index of each bird species of each transect, averaged the results within each vegetation type, clustered the averaged data and generated a dendogram. The dendogram contained several obvious clusters with similarity coefficients greater than 0.8. Other coefficients were as low as 0.5. These clusters were used as the basis for identifying the 18 breeding bird communities described on the following pages. In a few instances communities vary from the dendogram where small sample sizes or an unusual transect produced results which gave inconsistent vegetation groupings.

A consistent format is used to describe the breeding bird communities. After the community number, a name is given for the habitat characterizing that community, followed by a general description of the habitat, its dominant plants, the elevation range, and associated soils and landforms. Next follows a list of bird species that comprise the community. Dominant species are the species with density indices greater than ten. That is, they are the most frequent or prevailing species. Definitive species are those species which best serve to define the community. Species listed here are not found in other communities or if they are, they occur there at much lower densities. A species may be definitive of up to four communities where its density index is similar in those communities. Additonal species are all other species that were recorded on transects in that habitat with density indices less than ten.

The Remarks section describes the areal extent of the community, species which reach their maximum density in that community, species which are relatively common in that community and are listed on the National Audubon Society's Blue List (Tate 1981), and the total density index for the community. The Blue List is a list of species "which have

recently given or are currently giving indications of non-cyclical population declines or range contractions, either locally or widespread" (Anon [Arbib] 1971:948). As such, it is an early warning alert before a species is officially designated threatened or endangered. The last part of the community description is a list of vegetation types on which the community is found. Vegetation types are described in greater detail in Volume II. Bird communites that occur on each ecosite are presented in the wildlife map legend (Map Supplement) and the ecosite accounts in this volume.

Migrants and winter residents are not considered here since bird communities are considered to be characteristic assemblages of breeding birds associated with certain habitats.

BIRD COMMUNITY 1

Poplar forest

Habitat:

Aspen and balsam poplar forest with scattered white spruce and lodgepole pine. The understory is charaterized by a rich herb layer and sparse moss and lichen cover. Spruce may dominate the shrub layer, with prickly rose and buffaloberry depending on the forest type. Generally the soil is mesic and well-drained on alluvial fans or glacial till. Aspen forests are generally south or south-west facing slopes while balsam poplar is more variable in exposure. Extensive pure stands of aspen and balsam poplar are scarce in Banff and Jasper. Most are found in the montane ecoregion below 1500 m but some aspen stands on avalanche slopes extend up to 1600 m in the lower subalpine ecoregion. Poplar forests are commonest in the Bow valley downstream of Castle Junction, the Athabasca valley downstream of Sunwapta Falls, The Ghost Lakes and the Saskatchewan Crossing area.

Dominant Species:

Pine Siskin	(40)	Chipping Sparrow	(29)
Dark-eyed Junco	(23)	American Robin	(20)
Yellow-rumped Warbler	(19)	Warbling Vireo	(18)
Tree Swallow	(10)		

Definitive Species:

American Robin	(20)	Warbling Vireo	(18)
Tree Swallow	(10)	Swainson's Thrush	(9)
Black-capped Chickadee	(7)	Brown-headed Cowbird	(7)
Least Flycatcher	(6)	Orange-crowned Warbler	(5)
Downy Woodpecker	(4)	Red-breasted Nuthatch	(4)
Cooper's Hawk	(3)	Common Flicker	(2)
Common Starling	(2)	Yellow Bellied Sapsucker	(1)
Common Nighthawk	(1)	Long-eared Owl	(1)
Mourning Dove	(1)	Ruffed Grouse	(1)
Western Wood Peewee	(1)	Solitary Vireo	(1)

Additional Species:

Red Crossbill	(9)	Gray Jay	(5)
Dusky Flycatcher	(4)	Golden-crowned Kinglet	(4)
Ruby-crowned Kinglet	(4)	Cedar Waxwing	(4)
Mountain Chickadee	(3)	Calliope Hummingbird	(3)
White-crowned Sparrow	(3)	Boreal Chickadee	(2)
Townsend's Warbler	(2)	Yellow Warbler	(2)
Western Tanager	(2)	Northern Yellowthroat	(2)
Common Raven	(2)	Barn Swallow	(2)
Clay-coloured Sparrow	(2)	Barrow's Goldeneye	(1)
Clark's Nutcracker	(1)	American Redstart	(1)
Rufous Hummingbird	(1)	Common Snipe	(1)
White-winged Crossbill	(1)	Townsend's Solitaire	(1)
Black-billed Magpie	(1)	Wilson's Warbler	(1)
Hermit Thrush	(1)	Red-eyed Vireo	(+)
Pileated Woodpecker	(+)		

Remarks:

This bird community is restricted in areal extent and includes many species found in no other communities in Banff and Jasper. Where spruce and pine are common in the canopy the birds present include species of bird community 5. Species which reach their maximum densities here are: Cooper's Hawk, Ruffed Grouse, Long-eared Owl, Mourning Dove, Yellow-bellied Sapsucker, Western-wood Peewee, American Robin, Black-capped Chickadee and Warbling Vireo. Cooper's Hawk and Common Nighthawk are listed in the Blue List for 1981 (Tate 1981). Overall the average density index is high (297).

Vegetation type correlates:

aspen/hairy wild rye-peavine (C16)
balsam poplar/buffaloberry (C17)
aspen/hairy wild rye-showy aster (C22)
balsam poplar/horsetail (C28)

BIRD COMMUNITY 2

Stunted Aspen

Habitat:

Stunted aspen woodland on dry (subxeric) colluvial slopes between 1100 and 1400 m. These slopes are typically southwest-oriented with well-drained soils. The talus is often active with rubble exposed at the surface. The open forest is comprised of uneven-aged stunted aspens. The shrub, herb and moss layers are sparse except that bearberry may approach 50% cover. This vegetation is an intermediate successional stage maintained by active colluviation.

Dominant Species:

Pine Siskin	(100+)	Chipping Sparrow	(44)
Dusky Flycatcher	(42)	Rufous Hummingbird	(40)
Yellow-rumped Warbler	(30)	Dark-eyed Junco	(28)
Townsend's Solitaire	(17)		

Definitive Species:

Pine Siskin	(100+)	Dusky Flycatcher	(42)
Rufous Hummingbird	(40)	Townsend's Solitaire	(17)
Mountain Chickadee	(6)	Orange-crowned Warbler	(5)
Willow Flycatcher	(5)	Macgillivray's Warbler	(5)

Additional Species:

Brewer's Sparrow	(5)	Western Tanager	(3)
Common Crow	(3)	American Kestrel	(2)
Common Raven	(2)	Ruby-crowned Kinglet	(2)
Swainson's Thrush	(2)	Varied Thrush	(1)

Remarks:

This bird community is restricted in areal extent but occurs on steep slopes which are unlikely to be affected by human activities. Species which reach heir highest densities here are: Rufous Hummingbird, Dusky Flycatcher, Townsend's Solitaire, Yellow-rumped Warbler, Pine Siskin and Chipping Sparrow. American Kestrel and Willow Flycatcher are on the Blue List for 1981 (Tate 1981). The average density index for this community is high (421)

Vegetation type correlates:

aspen/hairy wild rye-peavine (C16)

BIRD COMMUNITY 3

Douglas-fir forest

Habitat:

Douglas-fir forest on xeric to subxeric, south-facing slopes in the montane and lower subalpine ecoregions between 1200 and 1750 m. The well to rapidly-drained soils are on till or colluvial slopes with up to 100% slope. The upper canopy of Douglas-fir is usually open, comprised of large old trees that have survived several fires. The ground cover is variable depending upon the vegetation type, however moss and lichen cover is poorly developed.

Dominant Species:

Dark-eyed Junco	(30)	Pine Siskin	(30)
Yellow-rumped Warbler	(27)	Chipping Sparrow	(25)
American Robin	(21)		

Definitive Species:

American Robin	(21)	Swainson's Thrush	(9)
Mountain Chickadee	(8)	Warbling Vireo	(7)
White-winged Crossbill	(7)	Brown-headed Cowbird	(7)
Western Tanager	(5)	Common Flicker	(2)
Bohemian Waxwing	(2)	Solitary Vireo	(2)
Red-eyed Vireo	(1)	Rough-winged Swallow	(1)

Additional Species:

Rufous Hummingbird	(9)	Ruby-crowned Kinglet	(3)
Townsend's Solitaire	(3)	Gray Jay	(3)
Common Crow	(3)	Calliope Hummingbird	(3)
Common Raven	(3)	Red-breasted Nuthatch	(2)
Golden-crowned Kinglet	(2)	Townsend's Warbler	(2)
Black-capped Chickadee	(1)	Dusky Flycatcher	(1)
Blue Grouse	(1)	Belted Kingfisher	(1)
Cedar Waxwing	(1)	Northern Waterthrush	(1)
Boreal Chickadee	(1)	Sharp-shinned Hawk	(1)
Black-billed Magpie	(1)		

Remarks:

Douglas-fir forests are very restricted in area and subject to destruction in the Bow valley along the Trans Canada Highway as well as occurring adjacent to roads and a railroad in Jasper National Park. This bird community has the highest breeding densities of Mountain Chickadee, American Robin, Bohemian Waxwing, Solitary Vireo, Western Tanager and Dark-eyed Junco. The average density index is high (24.1). This community has a 90% similarity coefficient to community 4.

Vegetation type correlates:

Douglas fir/hairy wild rye (C1)
Douglas fir/juniper/bearberry (O5)

BIRD COMMUNITY 4

Open spruce-pine forest

Habitat:

Open spruce forest in a variety of situations. Some forests include limber pine and others lodgepole pine. In some of these forests spruce is scattered (L1&L6) and in others the trees are continuous. All these forests are subxeric to xeric and occur on rapidly-drained soils. Some of these stands occupy steep south-facing colluvial veneers over rock while others occupy relatively level eolian deposits overlying fluvial or morainal deposits. These forests are found in the montane and lower subalpine between 1000 m and 1850 m. Ground cover is variable but typically there is a well-developed shrub layer of juniper, shrubby cinquefoil, buffaloberry and prickly rose. The herb layer is moderately well-developed while moss & lichen are sparse.

Dominant Species:

Chipping Sparrow	(34)	Pine Siskin	(25)
Yellow-rumped Warbler	(22)	Dark-eyed Junco	(21)

Definitive Species:

White-winged Crossbill	(6)	Black-billed Magpie	(3)
Vesper Sparrow	(3)	Common Flicker	(2)
Bohemian Waxwing	(2)	Common Nighthawk	(2)
Magnolia Warbler	(1)	Western Flycatcher	(1)

Additional Species:

American Robin	(9)	Common Crow	(8)
Ruby-crowned Kinglet	(7)	Gray Jay	(6)
Swainson's Thrush	(3)	Warbling Vireo	(3)
Mountain Chickadee	(3)	Boreal Chickadee	(2)
Common Raven	(2)	Cliff Swallow	(2)
Townsend's Solitaire	(2)	Goshawk	(2)
Hammond's Flycatcher	(2)	Lincoln's Sparrow	(1)
Blue Grouse	(1)	American Kestrel	(1)
Wilson's Warbler	(1)	Western Tanager	(1)
Rufous Hummingbird	(1)	Brown-headed Cowbird	(1)
Red-breasted Nuthatch	(1)	Savannah Sparrow	(1)

Song Sparrow	(1)	White-crowned Sparrow	(1)
Brewer's Sparrow	(1)		

Remarks:

This bird community is quite widespread. Relatively few species reach their maximum densities here, but these species are notable: Goshawk, Common Nighthawk and Western Flycatcher. However, all three species are relatively uncommon in the parks. The Common Nighthawk is listed on the Blue List for 1981 (Tate 1981). The density index for this community is medium (186). his community has a 90% similarity to community 3.

Vegetation type correlates:

limber pine-Douglas fir juniper/bearberry (02)
white spruce/shrubby cinquefoil/bearberry (03)
white spruce/juniper/bearberry (017)
shrubby cinquefoil/bearberry-northern bedstraw (L1)
creeping juniper-northern wheatgrass-sedge (L6)

BIRD COMMUNITY 5

Closed spruce-pine forest

Habitat:

This community occurs in most of the closed coniferous forests in the montane and lower subalpine ecoregions. The canopy is dominated by lodgepole pine and white spruce. Pure canopies of either species are less common than mixed canopies. Subalpine fir occurs in higher elevation stands and Douglas fir in lower stands. The shrub layer is variable with common species including prickly rose, buffaloberry, juniper and bearberry. Most soils are mesic, well-drained and derived from alluvial, morainal and eolian deposits. The elevation range is 1000-1900 m.

Dominant Species:

Pine Siskin	(28)	Yellow-rumped Warbler	(21)
Dark-eyed Junco	(20)	Chipping Sparrow	(10)
American Robin	(10)		

Definitive Species:

Gray Jay	(8)	Swainson's Thrush	(8)
Boreal Chickadee	(6)	Townsend's Warbler	(5)
Solitary Vireo	(1)	Northern Three-toed Woodpecker	(1)
Brown Creeper	(1)	Western Flycatcher	(5)

Additional Species:

Golden-crowned Kinglet	(8)	Ruby-crowned Kinglet	(5)
White-winged Crossbill	(4)	Mountain Chickadee	(3)

Brown-headed Cowbird	(2)	Warbling Vireo	(2)
Black-capped Chickadee	(2)	Spruce Grouse	(1)
Red-breasted Nuthatch	(1)	Townsend's Solitaire	(1)
Blackpoll Warbler	(1)	Orange-crowned Warbler	(1)
Common Crow	(1)	Clark's Nutcracker	(1)
Wilson's Warbler	(1)	Pine Grosbeak	(1)
Common Raven	(1)	Cedar Waxwing	(1)
Red Crossbill	(1)	Varied Thrush	(1)
Hermit Thrush	(1)	Brown Creeper	(1)

Remarks:

This widespread community is likely the commonest in these national parks. Only the Northern Three-toed Woodpecker reaches its highest density here. The density index of this community is medium (169). This community has a 90% similarity to community 8.

Vegetation type correlates:

white spruce/fern moss (C2)
lodgepole pine/juniper/bearberry (C3)
white spruce/prickly rose/horsetail (C4)
white spruce-Douglas fir/feathermoss (C5)
lodgepole pine/buffaloberry/showy aster (C6)
lodgepole pine/dwarf bilberry (C9)
lodgepole pine/green alder/feathermoss (C10)
lodgepole pine/feathermoss (C11)
lodgepole pine/buffaloberry/grouseberry (C18)
lodgepole pine/buffaloberry/twinflower (C19)
lodgepole pine/false azalea/grouseberry (C20)
white spruce/buffaloberry/fern moss (C26)
white spruce/prickly rose/fern moss (C27)
lodgepole pine/Labrador tea (C29)

BIRD COMMUNITY 6

Spruce bog forest

Habitat:

Bog forests dominated by black and white spruce. The canopy is usually open and the shrub, herb and moss layers are well-developed. Willows, labrador tea and dwarf birch are typical shrubs. The forests are on level or shallow, north-facing slopes. The soils are hygric to sub-hydric and poorly to very poorly drained. Most of these forest are on alluvial or morainal deposits in the lower subalpine ecoregion between 1200 and 1950 m.

Dominant Species:

Chipping Sparrow	(25)	Dark-eyed Junco	(24)
Pine Siskin	(22)	Yellow-rumped Warbler	(13)
Ruby-crowned Kinglet	(13)	Gray Jay	(10)
Blackpoll Warbler	(10)	White-winged Crossbill	(10)
American Robin	(10)		

Definitive Species:

Ruby-crowned Kinglet	(13)	Blackpoll Warbler	(10)
Gray Jay	(10)	White-winged Crossbill	(10)
Swainson's Thrush	(7)	Boreal Chickadee	(7)
Spruce Grouse	(4)	Common Snipe	(4)
Mourning Dove	(1)	Purple Finch	(1)

Additional Species:

Golden-crowned Kinglet	(7)	Evening Grosbeak	(4)
Townsend's Warbler	(2)	Lincoln's Sparrow	(2)
Brown-headed Cowbird	(2)	Red-winged Blackbird	(2)
Wilson's Warbler	(2)	White-crowned Sparrow	(2)
Mountain Chickadee	(2)	Hermit Thrush	(1)
Varied Thrush	(1)	Barn Swallow	(1)
Common Raven	(1)	American Bittern	(1)
Common Crow	(1)	Cedar Waxwing	(1)
Pine Grosbeak	(1)	Song Sparrow	(1)
Northern Three-toed Woodpecker	(1)	Orange-crowned Warbler	(1)
Spotted Sandpiper	(1)	Greater Yellowlegs	(5)

Remarks:

The species which reach their maximum densities in this bird community are Spruce Grouse, Gray Jay, Boreal Chickadee, Rubycrowned Kinglet, Blackpoll Warbler, Purple Finch, and White-winged Crossbill. The American Bittern is on the Blue List (Tate 1981). Wet spruce forest is wide spread but not common. The density index of this community is medium (203).

Vegetation type correlates:

black spruce-lodgepole pine/willow/sedge (C8)
Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6)
spruce/arrowgrass-sedge (O7)
spruce/Labrador tea/brown moss (O11)

BIRD COMMUNITY 7

Open upper subalpine coniferous forest

Habitat:

Open coniferous forests dominated by spruce and subalpine fir with lodgepole pine, subalpine larch and whitebark pine in some stands. Most of the soils are mesic to subhygric and thus the shrub layer is well-developed, dominated by willows and labrador tea, or heathers. The forests are generally on colluvial or morainal slopes, moderate to very steep, predominantly north-facing. These forests are found in the upper subalpine ecoregion from 1570 m to 2000 m.

Dominant Species:

Pine Siskin	(27)	Chipping Sparrow	(16)
Dark-eyed Junco	(14)		

Definitive Species:

Hermit Thrush	(3)	Fox Sparrow	(3)
Varied Thrush	(2)	Winter Wren	(1)

Additional Species:

Yellow-rumped Warbler	(8)	American Robin	(8)
Ruby-crowned Kinglet	(5)	Gray Jay	(5)
White-crowned Sparrow	(4)	Boreal Chickadee	(4)
Water Pipit	(3)	Golden-crowned Kinglet	(3)
Gray-crowned Rosy Finch	(3)	Townsend's Solitaire	(3)
Blue Grouse	(2)	Clark's Nutcracker	(2)
Mountain Chickadee	(2)	White-winged Crossbill	(2)
Red Crossbill	(2)	Brewer's Sparrow	(2)
Golden-crowned Sparrow	(1)	Swainson's Thrush	(1)
Mountain Bluebird	(1)	Black-capped Chickadee	(1)
Evening Grosbeak	(1)	Spotted Sandpiper	(1)
Townsend's Warbler	(1)	Savannah Sparrow	(1)
Pine Grosbeak	(1)	Calliope Hummingbird	(1)

Remarks:

The Blue Grouse is the only species which reaches its highest density in this bird community. This community is widespread at treeline, however its extent is limited because of the generally narrow elevational range of timberline. The density index for this community is medium (141).

Vegetation type correlates:

Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4)
Engelmann spruce-subalpine fir/valerian-fleabane (O9)
Engelmann spruce-subalpine fir/heather (O10)
Engelmann spruce-subalpine fir/rock willow/alpine bearberry (O12)
open subalpine larch/heath forest
Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14)
Engelmann spruce-subalpine fir/willow/hairy wild rye (O18)

BIRD COMMUNITY 8

Closed subalpine coniferous forest

Habitat:

Spruce and subalpine fir-dominated closed subalpine forests, with menziesia, grouseberry, rhododendron or labrador tea in the shrub layer. The herb layer is variable in cover and composition but the moss layer is generally well-developed. These forests occur on shallow to steep slopes of variable aspect. The soils are mesic to subhygric, derived from morainal landforms although colluvial and eolian parent materials may also be present. These habitats occur between 1200 m and 2350 m in the lower and upper subalpine forests.

Dominant Species:

Pine Siskin	(31)	Golden-crowned Kinglet	(20)
Yellow-rumped Warbler	(13)		

Definitive Species:

Golden-crowned Kinglet	(20)	Gray Jay	(7)
Boreal Chickadee	(6)	Townsend's Warbler	(5)
Winter Wren	(3)	Hermit Thrush	(2)
Varied Thrush	(2)	Pine Grosbeak	(2)
Northern Three-toed Woodpecker	(1)	Brown Creeper	(1)
Boreal Owl	(+)		

Additional Species:

Chipping Sparrow	(9)	Dark-eyed Junco	(4)
Ruby-crowned Kinglet	(4)	Swainson's Thrush	(4)
White-winged Crossbill	(3)	Clark's Nutcracker	(2)
Mountain Chickadee	(2)	Spruce Grouse	(2)
American Robin	(1)	Red Crossbill	(1)
Red-breasted Nuthatch	(1)	Wilson's Warbler	(1)
Brown Creeper	(1)	Townsend's Solitaire	(1)
White-crowned Sparrow	(1)	Blackpoll Warbler	(1)
Evening Grosbeak	(1)		

Remarks:

This bird community is one of the most extensive in Banff and Jasper. Species which reach their maximum density are Boreal Owl, Brown Creeper, Varied Thrush, Golden-crowned Kinglet and Townsend's Warbler. The Golden-crowned Kinglet is on the Blue List (Tate 1981). The density index of this community is medium (140). This community has a 90% similarity to community 5.

Vegetation type correlates:

Engelmann spruce-whitebark pine/false azalea (C12)
Engelmann spruce-subalpine fir/feathermoss (C13)
Engelmann spruce-subalpine fir/false azalea (C14)
Engelmann spruce-subalpine fir/grouseberry (C15)
Engelmann spruce-subalpine fir/tall bilberry/liverwort (C21)
subalpine larch-subalpine fir/grouseberry-everlasting (C23)
Engelmann spruce-subalpine fir/rock willow/white mountain heather (C24)
Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30)
Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31)
Engelmann spruce/horsetail/feathermoss (C32)
Engelmann spruce/hairy wild rye (C33)

BIRD COMMUNITY 9

Montane Shrub Wetland

Habitat:

The shrub layer is well-developed, dominated by birch, willows, shrubby cinquefoil and occasional balsam poplar. The herb layer is moderately to well-developed. Sedges are common. These meadows are usually on alluvial areas or along the edges of kettle lakes and receive periodic flooding. The soils are hydric to hygric. The elevational range is 900 m to 2050 m, in the montane and lower subalpine ecoregions.

Dominant Species:

Northern Yellowthroat	(46)	Red-winged Blackbird	(38)
Lincoln's Sparrow	(35)	Pine Siskin	(23)
Common Crow	(14)	Ring-necked Duck	(13)
Mallard	(13)	Brown-headed Cowbird	(12)
Tree Swallow	(12)	Savannah Sparrow	(11)
Yellow Warbler	(11)	American Robin	(11)
Eastern Kingbird	(11)	Blue-Winged Teal	(10)
Evening Grosbeak	(10)	Orange-crowned Warbler	(10)

Definitive Species:

Northern Yellowthroat	(46)	Red-winged Blackbird	(38)
Lincoln's Sparrow	(35)	Common Crow	(14)
Mallard	(13)	Ring-necked Duck	(13)
Brown-headed Cowbird	(12)	Yellow Warbler	(11)
Eastern Kingbird	(11)	Blue-Winged Teal	(10)
Evening Grosbeak	(10)	Orange-crowned Warbler	(10)
Willow Flycatcher	(9)	Rufous Hummingbird	(9)
Common Snipe	(9)	Cedar Waxwing	(9)
White-crowned Sparrow	(8)	Song Sparrow	(5)
Clay-coloured Sparrow	(5)	Osprey	(3)
Black-billed Magpie	(3)	Greater Yellowlegs	(3)
American Kestrel	(2)	Sora	(2)
Common Flicker	(2)	Alder Flycatcher	(2)
American Bittern	(2)	Common Starling	(2)
Bohemian Waxwing	(2)	Common Merganser	(1)

Additional Species:

American Redstart	(6)	Cinnamon Teal	(6)
Warbling Vireo	(6)	Gray Jay	(5)
Chipping Sparrow	(5)	Ruby-crowned Kinglet	(4)
Green-winged Teal	(4)	Spotted Sandpiper	(4)
Boreal Chickadee	(4)	Least Flycatcher	(3)
Black-capped Chickadee	(3)	Dark-eyed Junco	(3)
Barn Swallow	(2)	Wilson's Warbler	(2)
Mountain Chickadee	(2)	Common Raven	(2)
Swainson's Thrush	(2)	Belted Kingfisher	(1)
Yellow-rumped Warbler	(1)	Killdeer	(1)
Macgillivray's Warbler	(1)	Barrow's Goldeneye	(1)
Blackpoll Warbler	(1)	Brewer's Sparrow	(1)
Red-eyed Vireo	(1)	Olive-sided Flycatcher	(1)

Red-breasted Nuthatch	(1)	Ruffed Grouse	(1)
Western Wood Peewee	(1)	Pileated Woodpecker	(1)
Tennessee Warbler	(1)		

Remarks:

This community is very restricted in extent in the two national parks. It is almost wholly confined to the Bow and Athabasca valleys where most facilities and recreation activities are concentrated. Waterfowl reaching their maximum densities here include Canada Goose, Mallard, Blue-winged Teal, Ring-necked Duck and Common Merganser. Many other species occur at maximum densities including: Red-necked Grebe, American Bittern, Osprey, American Kestrel, Sora, Common Snipe, Greater Yellowlegs, Belted Kingfisher, Pileated Woodpecker, Eastern Kingbird, Willow Flycatcher, Alder Flycatcher, Tree Swallow, Black-billed Magpie, Common Crow, Cedar Waxwing, Yellow Warbler, Common Yellowthroat, Red-winged Blackbird, Evening Grosbeak, Clay-colored Sparrow, Lincoln's Sparrow and Song Sparrow. Several of the species which occur here are listed in the Blue List for 1981: Red-necked Grebe, American Bittern, American Kestrel, Willow Flycatcher, Yellow Warbler and Common Yellowthroat. This community has the highest density index (436) of all the bird communities in these national parks and is consequently one of the most important communities in the parks. This community is frequently associated with montane lakes (AQ1 and AQ2) and the VL ecosection.

Vegetation type correlates:

dwarf birch-shrubby cinquefoil-willow/brown moss (S1)
dwarf birch-shrubby cinquefoil/needlerush (S3)
willow/horsetail (S7)

BIRD COMMUNITY 10

Subalpine willow-birch meadows

Habitat:

Subalpine shrub meadows dominated by willows especially *Salix glauca* , dwarf birch and grasses. The grass cover is variable. These meadows are level to moderately steep with south exposures. The soil moisture is variable. These meadows are usually on alluvial fans and colluvial blankets from 1600 m to 2300 m elevation.

Dominant Species:

White-crowned Sparrow	(24)	Savannah Sparrow	(21)
Chipping Sparrow	(21)		

Definitive Species:

White-crowned Sparrow	(24)	Savannah Sparrow	(21)
Spotted Sandpiper	(8)	Wilson's Warbler	(7)
Brewer's Sparrow	(4)	Brewer's Blackbird	(4)
Harlequin Duck	(0.4)		

Additional Species:

Pine Siskin	(9)	American Robin	(8)
Dark-eyed Junco	(7)	Gray Jay	(4)
Lincoln's Sparrow	(4)	Yellow-rumped Warbler	(4)
Ruby-crowned Kinglet	(3)	Water Pipit	(2)
Northern Yellowthroat	(2)	Clay-coloured Sparrow	(2)
Boreal Chickadee	(1)	Fox Sparrow	(1)
Golden-crowned Kinglet	(1)	Hermit Thrush	(1)
Townsend's Solitaire	(1)	Mallard	(1)
Golden-crowned Sparrow	(1)	Mountain Chickadee	(1)
Willow Flycatcher	(1)	Orange-crowned Warbler	(1)
Gray-crowned Rosy Finch	(1)	Green-winged Teal	(1)
Killdeer	(1)	Song Sparrow	(1)

Remarks:

Subalpine shrub meadows are found in many alluvial areas in the parks. Brewer's Blackbirds occur in this community only at low elevations, where they reach their maximum densities. In this community Harlequin Ducks and White-crowned Sparrow were recorded at maximum densities. The density index of this community is low (156). This bird community is also associated with subalpine lakes (AQ4, AQ5). This community has a 72% similarity to community 14.

Vegetation type correlates:

willow-dwarf birch/fleabane (S4)
willow/cinquefoil (S8)
dwarf birch-willow/kobresia (S9)
willow-dwarf birch-shrubby cinquefoil (S10)
willow/timber oatgrass (S11)
willow/hairy wild rye (S12)
unspecified herb meadow (H18)

BIRD COMMUNITY 11

Alder thicket

Habitat:

Alders dominate this habitat, which occurs only in Jasper. Thimbleberry, prickly rose and willows are other common shrubs. The herb layer is well-developed. These thickets are found on north and east-facing, moderately steep slopes derived from colluvial, morainal or fluvial deposits. Seepage results in hygric soils. This habitat occurs between 1300 m and 1600 m in the montane and lower subalpine ecoregions.

Dominant Species:

Wilson's Warbler	(60)	American Redstart	(27)
Chipping Sparrow	(26)	Warbling Vireo	(25)
Dark-eyed Junco	(20)	Brown-headed Cowbird	(17)
Spotted Sandpiper	(17)	Least Flycatcher	(16)
Orange-crowned Warbler	(16)	Northern Yellowthroat	(12)
Pine Siskin	(12)	Hammond's Flycatcher	(10)
Swainson's Thrush	(10)	Yellow-rumped Warbler	(10)

Definitive Species:

Wilson's Warbler	(60)	American Redstart	(27)
Warbling Vireo	(25)	Brown-headed Cowbird	(17)
Least Flycatcher	(16)	Spotted Sandpiper	(16)
Orange-crowned Warbler	(16)	Northern Yellowthroat	(12)
Tree Swallow	(12)	Swainson's Thrush	(10)
Macgillivray's Warbler	(9)	Tennessee Warbler	(9)
Sharp-shinned Hawk	(8)	Yellow Warbler	(8)
Dusky Flycatcher	(7)	Northern Waterthrush	(5)
Red-breasted Nuthatch	(4)	Varied Thrush	(2)

Additional Species:

American Robin	(9)	Golden-crowned Kinglet	(9)
Savannah Sparrow	(6)	Common Raven	(4)

Remarks:

This vegetation type is very restricted in areal extent, yet very highly important to breeding birds. The following species reach maximum numbers here: Sharp-shinned Hawk, Least Flycatcher, Hammond's Flycatcher, Common Raven, Red-breasted Nuthatch, Swainson's Thrush, Warbling Vireo, Tennessee Warbler, Orange-crowned Warbler, Northern Waterthrush, MacGillivary's Warbler, Wilson's Warbler, American Redstart, and Brown-headed Cowbird. Sharp-shinned Hawk and Yellow Warbler are on the Blue List for 1981 (Tate 1981). The density index of this community is high (350).

Vegetation type correlates:

undefined willow shrubbery
willow-green alder/bluebell (S6)

BIRD COMMUNITY 12

Avalanche Slopes

Habitat:

Steep avalanche chutes, typically dominated by low-growing subalpine fir but may include rhododendron, menziesia and/or willows. The shrub species composition is highly variable. Seepage is common on the colluvial parent material. These slopes occur between 1700 m and 2150 m, mostly in the upper subalpine ecoregion.

Dominant Species:

Pine Siskin	(23)	Dark-eyed Junco	(20)
Wilson's Warbler	(19)	Chipping Sparrow	(16)
Rufous Hummingbird	(14)	Yellow-rumped Warbler	(10)

Definitive Species:

Wilson's Warbler	(19)	Rufous Hummingbird	(14)

Brewer's Sparrow	(9)	Clark's Nutcracker	(6)
Gray-crowned Rosy Finch	(6)	Orange-crowned Warbler	(6)
Hermit Thrush	(6)	Townsend's Warbler	(5)
White-crowned Sparrow	(4)	Winter Wren	(4)
Fox Sparrow	(3)	Olive-sided Flycatcher	(3)
Golden-crowned Sparrow	(2)	Alder Flycatcher	(2)
Northern Three-toed Woodpecker	(1)		

Additional Species:

American Robin	(8)	Golden-crowned Kinglet	(5)
Townsend's Solitaire	(5)	Ruby-crowned Kinglet	(4)
Warbling Vireo	(4)	Gray Jay	(4)
Macgillivray's Warbler	(3)	American Redstart	(3)
Yellow Warbler	(2)	Alder Flycatcher	(2)
Dusky Flycatcher	(2)	Mountain Chickadee	(2)
White-winged Crossbill	(1)	Blue Grouse	(1)
Water Pipit	(1)	Northern Three-toed Woodpecker	(1)
Swainson's Thrush	(1)	Varied Thrush	(1)
Common Raven	(1)	Red-breasted Nuthatch	(1)
Solitary Sandpiper	(1)	Common Crow	(1)
Golden Eagle	(1)		

Remarks:

This bird community is widespread but patchy in these national parks. Species which reach maximum densities are Alder Flycatcher, Olive-sided Flycatcher, Clark's Nutcracker, Winter Wren, Hermit Thrush and Fox Sparrow. The density index for this community is medium (210).

Vegetation type correlates:

subalpine fir-willow (S2)

BIRD COMMUNITY 13

Montane Grassland

Habitat:

This community occurs on low-elevation grasslands, frequently with scattered clumps and individuals of lodgepole pine and white spruce. Grasses are dominant, including junegrass, wheatgrass, oatgrass and needle grass. This habitat occurs on south-facing alluvial fans and steep slopes underlaid with till or loess. There is sparser growth and more exposed soil on steep slopes. The elevational range is 1000 - 1500 m, in the montane ecoregion.

Dominant Species:

Pine Siskin	(37)	Dark-eyed Junco	(34)
Red Crossbill	(32)	Chipping Sparrow	(18)
Calliope Hummingbird	(17)	Yellow-rumped Warbler	(17)

Definitive Species:

Calliope Hummingbird	(17)	Warbling Vireo	(8)
Swainson's Thrush	(8)	Vesper Sparrow	(6)
Orange-crowned Warbler	(5)	Wilson's Warbler	(5)
Red-breasted Nuthatch	(4)	Common Flicker	(3)

Additional Species:

American Robin	(9)	Hammond's Flycatcher	(7)
Golden-crowned Kinglet	(4)	Gray Jay	(4)
Mountain Chickadee	(3)	Townsend's Warbler	(3)
Lincoln's Sparrow	(2)	Black-billed Magpie	(1)

Remarks:

Montane grasslands are a very restricted habitat which has been encroached upon extensively, especially in the Bow valley. Species which reach their maximum densities include Calliope Hummingbird, Common Flicker, Vesper Sparrow, and Dark-eyed Junco. The density index of this community is medium (228).

Vegetation type correlates:

junegrass-pasture sage-wild blue flax (H6)
wheatgrass-pasture sage (H7)

BIRD COMMUNITY 14

Sedge or Cottongrass Fen

Habitat:

This community occurs in mosaics of small ponds and wet meadows over an elevation range of 1100 m to 2300 m. The vegetation is dominated by cottongrass or sedges but is generally species-poor. These montane to upper subalpine fens are usually on poorly-drained alluvial areas.

Dominant Species:

Savannah Sparrow	(46)	Pine Siskin	(24)
Northern Yellowthroat	(23)	Green-winged Teal	(18)
Lincoln's Sparrow	(18)	Red-winged Blackbird	(16)
American Robin	(13)	White-crowned Sparrow	(12)
Spotted Sandpiper	(12)	Chipping Sparrow	(11)
Killdeer	(11)	Barn Swallow	(11)

Definitive Species:

Savannah Sparrow	(46)	Northern Yellowthroat	(23)
Lincoln's Sparrow	(18)	Green-winged Teal	(18)
Red-winged Blackbird	(16)	White-crowned Sparrow	(13)
Leconte's Sparrow	(12)	Spotted Sandpiper	(12)
Barn Swallow	(11)	Killdeer	(11)
Gray Jay	(9)	Solitary Sandpiper	(7)

Common Snipe	(4)	Spruce Grouse	(4)
Eastern Kingbird	(3)	Greater Yellowlegs	(3)
Varied Thrush	(2)	Mountain Bluebird	(1)

Additional Species:

Dark-eyed Junco	(7)	Tree Swallow	(6)
Common Crow	(6)	Ruby-crowned Kinglet	(6)
Blue-Winged Teal	(5)	Golden-crowned Kinglet	(3)
Brown-headed Cowbird	(3)	Water Pipit	(3)
Swainson's Thrush	(2)	Tennessee Warbler	(2)
Yellow-rumped Warbler	(2)	American Kestrel	(2)
Barrow's Goldeneye	(2)	Horned Grebe	(2)
Yellow Warbler	(1)		
Alder Flycatcher	(1)		
Northern Waterthrush	(1)		
Sora	(1)		
Townsend's Warbler	(1)		
Olive-sided Flycatcher	(1)		
Belted Kingfisher	(1)		
Common Raven	(1)		
Warbling Vireo	(1)		
Cliff Swallow	(1)		
Common Flicker	(1)		

Remarks:

Birds which occur at maximum density here are Green-winged Teal, Barrow's Goldeneye, Killdeer, Solitary Sandpiper, Greater Yellowlegs, Barn Swallow, Mountain Bluebird, Savannah Sparrow and LeConte's Sparrow. These fens are not common in the mountains. American Kestrel, Mountain Bluebird and Common Yellowthroat are on the Blue List for 1981 (Tate 1981). The density index of this community is high (322). This community has as 72% similarity to community 10.

Vegetation type correlates:

cottongrass/moss (H10)
water sedge-beaked sedge (H11)

BIRD COMMUNITY 15

Dryas Mat

Habitat:

This community occurs on large river floodplains where the stream is actively aggrading and flooding occurs annually. The coarse textured calcareous alluvium is only partly vegetatated. Yellow dryad and willow herb are dominant, with willows and spruce present on more stable portions of the floodplain. These floodplains occur from 1200 m to 1950 m in the montane and subalpine ecoregions, particularly on glacial streams.

Dominant Species:

Pine Siskin	(12)	Chipping Sparrow	(11)

Definitive Species:

Spotted Sandpiper	(8)

Additional Species:

Savannah Sparrow	(3)	American Robin	(2)

Remarks:

No species occur at maximum densities and this community has the lowest density index of all communities in the parks (37).

Vegetation type correlates:

yellow dryad–willow herb (H8)

BIRD COMMUNITY 16

Upper Subalpine Grassland

Habitat:

Steep sub–xeric upper subalpine slopes with grasslands dominated by *Kobresia*, junegrass, hairy wildrye, mountain avens, juniper, willow and prickly rose. These slopes are usually south–facing and comprised of colluvium. Some are active talus slopes while others are avalanche tracks. Mosses and lichens are sparse, and the herb layer varies from dense to sparse. These slopes occur between 1600 m and 2400 m in the subalpine and lower portions of the alpine ecoregion, mainly in the Front Ranges.

Dominant Species:

Pine Siskin	(21)	Chipping Sparrow	(16)
Brewer's Sparrow	(12)		

Definitive Species:

Brewer's Sparrow	(12)	Townsend's Solitaire	(7)
White–crowned Sparrow	(4)		

Additional Species:

American Robin	(8)	Dark–eyed Junco	(7)
Gray–crowned Rosy Finch	(4)	Yellow–rumped Warbler	(3)
Water Pipit	(3)	Gray Jay	(3)
Golden–crowned Kinglet	(2)	Clark's Nutcracker	(2)
Wilson's Warbler	(1)	Ruby–crowned Kinglet	(1)
Common Flicker	(1)	Brown–headed Cowbird	(1)

Remarks:

Brewer's Sparrow is the only species that is at maximum density in this community. This community is not common in the national parks. The density index is low (99).

Vegetation type correlates:

mountain avens–kobresia–bearberry (H4)
hairy wild rye–junegrass–bearberry (H14)
juniper–willow (L2)

BIRD COMMUNITY 17

Moist Upper Subalpine and Alpine Meadows

Habitat:

High elevation meadows dominated by herbs such as mountain marigold and globe flower, or fleabane and valerian, or heathers. There may be tree islands or krummholz but the shrub layer is always sparse. The moss and lichen cover is variable. Seepage, convex slopes and high snow accumulation all contribute to high soil moisture. The slopes are shallow to moderately steep, usually morainal, and of variable aspect. These meadows occur between 2000 m and 2600 m in the upper subalpine and alpine ecoregions, most commonly in the Main Ranges.

Dominant Species:

Water Pipit	(27)	Gray–crowned Rosy Finch	(16)

Definitive Species:

Water Pipit	(27)	Gray–crowned Rosy Finch	(17)
Golden–crowned Sparrow	(6)	Clark's Nutcracker	(4)
Willow Ptarmigan (Jasper only)	3	Mountain Bluebird	(1)

Additional Species:

American Robin	(8)	Chipping Sparrow	(6)
Savannah Sparrow	(4)	Dark–eyed Junco	(3)
American Redstart	(2)	Spotted Sandpiper	(2)
White–crowned Sparrow	(2)	Horned Lark	(2)
Brewer's Sparrow	(2)	Common Raven	(2)
Townsend's Solitaire	(2)	Yellow–rumped Warbler	(1)
White–tailed Ptarmigan	(1)	Fox Sparrow	(1)
American Dipper	(1)	Pine Siskin	(1)
Boreal Chickadee	(1)	Song Sparrow	(1)

Remarks:

Water Pipit, Golden–crowned Sparrow and (in Jasper only) Willow Ptarmigan occur at maximum densities in this community. Moist high–elevation meadows are uncommon in the national parks. The Mountain Bluebird is on the Blue List for 1981 (Tate 1981). The density index for this community is low (97). This community has a 63% similarity to

community 18.

Vegetation type correlates:

mountain marigold-globeflower (H9)
fleabane-valerian (H16)
white mountain heather-mountain avens-snow willow (L4)
heather-everlasting (L5)

BIRD COMMUNITY 18

Dry Alpine Tundra

Habitat:

Dry tundra dominated by mountain avens, snow willow, moss campion, blueberry and *Kobresia*. This habitat is commonest in the Front Ranges and on colluvial or morainal slopes of variable steepness and aspect. Dry tundra occurs between 2150 m and 2550 m in the alpine ecoregion.

Dominant Species:

Horned Lark	(26)	Water Pipit	(26)
Gray-crowned Rosy Finch	(22)		

Definitive Species:

Horned Lark	(26)	Water Pipit	(26)
Gray-crowned Rosy Finch	(22)	White-tailed Ptarmigan	(7)
Brewer's Sparrow	(4)	Golden-crowned Sparrow	(3)

Additional Species:

American Robin	(5)	Pine Siskin	(3)
Chipping Sparrow	(2)	Common Raven	(2)
White-crowned Sparrow	(1)	Blue Grouse	(1)
Townsend's Solitaire	(1)		

Remarks:

Species which reach maximum densities in this community are White-tailed Ptarmigan, Horned Lark, Water Pipit and Gray-crowned Rosy Finch. This bird community is more widespread than the previous one. The density index for this community is low (104). This community has a 63% similarity to community 17.

Vegetation type correlates:

mountain avens-snow willow-moss campion (H1)
unspecified herb meadow (H17)

5.2. SMALL MAMMAL ASSOCIATIONS

Small mammal associations are groups of insectivores and small rodents that are often found together due to similar habitat . preference. The 11 species (deer mouse red-backed vole, heather vole, least chipmunk, long-tailed vole, masked shrew, meadow vole, northern bog lemming, vagrant shrew, western jumping mouse and yello pine chipmunk) considered here are those which are relatively reliably sampled by snap trapping

Associations were derived by the following method. The average catch per 100 trap nights was calculated for each of the 11 species captured in each of the sampled vegetation types. (Snap trap results and pitfall trap result were pooled for this analysis) A cluster analysis was applied to the catch per effort table. This generated a dendogram which linked vegetation types with similar catches of small mammals. In each cluster of vegetation types, the characteristic small mammals of each vegetation type and the descriptions of the vegetation types were examined for unifying factors. Vegetation type H10 (no captures) and vegetation types H16, O12 and S2 (related to other vegetation types with a co-efficient of similarity less than 0.78) are not considered.

In the following discussion dominant, definitive and additional species are listed. Dominant species are those species which have capture rates exceeding 1 per 100 trap nights. Definitive species are species which reach maximum densities in that association. Some definitive species may also be dominant. Additional species are all other species trapped on the vegetation types in the cluster. The average catch per 100 trap nights (in the vegetation types of the cluster) appears after each species listed.

SMALL MAMMAL ASSOCIATION I

Habitat:

Mesic to subxeric sites from the montane to the alpine; most frequently in the montane and lower subalpine. Soils are derived from till, fluvial or colluvial materials. Vegetation reflects the relatively dry soil conditions: grasslands dominated by wheatgrass or mountain avens, juniper/shrub meadows and forests composed of Douglas fir, white spruce and Engelmann spruce with understories of grasses (*Elymus*, *Festuca* and *Calamagrostis*), juniper, buffaloberry, shrubby cinquefoil, bearberry, twinflower and asters.

Dominant Species:

Deer mouse	7.9

Definitive Species:

Deer mouse	7.9		
Least chipmunk	0.4	Masked shrew	0.3

Additional Species:

Gapper's red-backed vole	0.6		
Meadow vole	0.5	Long-tailed vole	0.4
Heather vole	0.3	Western jumping mouse	0.1
Vagrant shrew	0.1	Yellow pine chipmunk	0.03
Northern bog lemming	0.01		

Remarks:

This association shows a clear numerical domination by deer mouse. Deer mice were captured at a rate of 17.2 per 100 trap nights in forests (C1, C5, C7, O2, O3, O5), 8.5 in shrubby meadows (L1, L6) and 5.6 in grasslands (H4, H7, H8).

Vegetation type correlates:

Douglas fir/hairy wild rye (C1)
white spruce/fern moss (C2)
lodgepole pine/juniper/bearberry (C3)
white spruce/prickly rose/horsetail (C4)
white spruce-Douglas fir/feathermoss (C5)
lodgepole pine/buffaloberry/showy aster (C6)
Douglas fir/pinegrass/lichen (C7)
Engelmann spruce-whitebark pine/false azalea (C12)
aspen/hairy wild rye-peavine (C16)
balsam poplar/buffaloberry (C17)
aspen/hairy wild rye-showy aster (C22)
white spruce/prickly rose/fern moss (C27)
Engelmann spruce-subalpine fir/hairy wild rye-heartleaf arnica-twinflower/feathermoss (C31)
Engelmann spruce/hairy wild rye (C33)
aspen/prickly rose/bearberry (O1)
limber pine-Douglas fir juniper/bearberry (O2)
white spruce/shrubby cinquefoil/bearberry (O3)
Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4)
Douglas fir/juniper/bearberry (O5)

white spruce/juniper/bearberry (O17)
Engelmann spruce-subalpine fir/willow/hairy wild rye (O18)
Engelmann spruce-subalpine fir/mountain avens (O19)
willow-green alder/bluebell (S6)
dwarf birch-willow/kobresia (S9)
shrubby cinquefoil/bearberry-northern bedstraw (L1)
spotted saxifrage-hairy wildrye (L3)
white mountain heather-mountain avens-snow willow (L4)
creeping juniper-northern wheatgrass-sedge (L6)
arctic willow-cinquefoil (L7)
mountain avens-snow willow-moss campion (H1)
mountain avens-kobresia-bearberry (H4)
junegrass-pasture sage-wild blue flax (H6)
wheatgrass-pasture sage (H7)
hairy wild rye-junegrass-bearberry (H14)
mountain avens-bearberry-*Kobresia* (H17)

SMALL MAMMAL ASSOCIATION II

Habitat:

This association occurs mainly in the lower subalpine, but also in the montane and upper subalpine. Soils are mesic, derived from till or from colluvial, glaciofluvial or fluvial material. This association usually occurs in closed forests of Englemann spruce, lodgepole pine, white spruce, and subalpine fir with shrub and moss understories. Common plants of the understory include juniper, buffaloberry, grouseberry, crowberry, false azalea, heather, twinflower and grasses (*Elymus* and *Calamagrostis*).

Dominant Species:

Deer mouse	3.2	Gapper's red-backed vole	2.9

Definitive Species:

Deer mouse	3.2	Gapper's red-backed vole	2.9

Additional Species:

Meadow vole	0.6	Yellow pine chipmunk	0.6
Western jumping mouse	0.2	Heather vole	0.2
Masked shrew	0.1	Least chipmunk	1.1
Long-tailed vole	0.1	Vagrant shrew	0.1

Remarks:

This association shows some similarities to Association I among the additional species, but the red-backed vole averages 5.2 times more numerous and the deer mouse 2.5 times less numerous in this association. The similarity coefficient between Associations I and II is 0.78.

Red-backed voles were captured at a rate of 1.94 per 100 trap nights in lodgepole pine forest (C9, C29), 2.41 in Englemann spruce.subalpine fir forest (C13, C21) and 3.90 in lodgepole pine.spruce forest (C10, C18, C19, C26).

Vegetation type correlates:

lodgepole pine/dwarf bilberry (C9)
lodgepole pine/green alder/feathermoss (C10)
Engelmann spruce–subalpine fir/feathermoss (C13)
lodgepole pine/buffaloberry/grouseberry (C18)
lodgepole pine/buffaloberry/twinflower (C19)
Engelmann spruce–subalpine fir/tall bilberry/liverwort (C21)
white spruce/buffaloberry/fern moss (C26)
lodgepole pine/Labrador tea (C29)
willow–dwarf birch/fleabane (S4)
juniper–willow (L2)

SMALL MAMMAL ASSOCIATION III

Habitat:

This association occurs in the subalpine ecoregion, mainly in the lower subalpine. Like Association II, soils are mainly derived from till or from colluvium. This association occurs mainly in mesic to hygric habitats, including closed and open forests of Engelmann spruce, white spruce, subalpine fir and lodgepole pine with understories of mosses, shrubs and some herbs. It also occurs in black spruce and willow bogs.

Dominant Species:

Gapper's red-backed vole	4.2

Definitive Species:

Gapper's red-backed vole	4.2	Masked shrew	0.2
Yellow pine chipmunk	0.2		

Additional Species:

Meadow vole	0.2	Heather vole	0.2
Deer mouse	0.2	Western jumping mouse	0.1
Northern bog lemming	0.1	Vagrant shrew	0.1
Least chipmunk	0.04		

Remarks:

As in Association II, the red-backed vole is numerically dominant but in this association the deer mouse is relatively rare. Masked and dusky shrews may be found in high numbers. Red-backed voles were captured at a rate of 0.87 per 100 trap nights in open spruce forest (O6, O15), 1.57 in open black spruce forest (O11), 3.69 in Engelmann spruce.subalpine fir forest (C14, C15, C24, C30, O14), 4.19 in lodgepole pine.spruce forest (C11, C35) and 15.60 in lodgepole pine forest (C20). This association is most similar to Associations V and VI.

Vegetation type correlates:

lodgepole pine/feathermoss (C11)
Engelmann spruce–subalpine fir/false azalea (C14)

Engelmann spruce-subalpine fir/grouseberry (C15)
lodgepole pine/false azalea/grouseberry (C20)
Engelmann spruce-subalpine fir/rock willow/white mountain heather (C24)
Engelmann spruce-subalpine fir/Labrador tea/crowberry (C30)
lodgepole pine-(Engelmann spruce)/crowberry/lichen (C35)
Engelmann spruce-subalpine fir/willow/ribbed bog moss (O6)
spruce/Labrador tea/brown moss (O11)
Engelmann spruce-subalpine fir/rock willow/bracted lousewort (O14)
spruce/Labrador tea/horsetail/peat moss (C15)

SMALL MAMMAL ASSOCIATION IV

Habitat:

This association is commonest in the lower subalpine, but occurs from the montane to the alpine on hygric to subhygric sites with soils derived from till or fluvial material. Cover is usually herbs or shrubs. Black spruce dominates the tree canopy in forested sites.

Dominant Species:

Meadow vole	3.1

Definitive Species:

Meadow vole	3.1	Northern bog lemming	0.5
Western jumping mouse	0.3	Masked shrew	0.2

Additional Species:

Gapper's red-backed vole	0.3	Deer mouse	0.2
Vagrant shrew	0.2	Long-tailed vole	0.1
Heather vole	0.1	Least chipmunk	001

Remarks:

The meadow vole is numerically dominant over the other small mammal species. Northern bog lemming, masked shrew and western jumping mouse may occur at high densites. The capture rate for meadow voles was 1.32 per 100 trap nights in shrubby meadows (S1, S3), 1.86 in black spruce (H9, H11) and 4.80 in willow thickets (S7, S8). This association and Association VII have a similarity coefficient of 0.74.

Vegetation type correlates:

black spruce-lodgepole pine/willow/sedge (C8)
Engelmann spruce-subalpine fir/valerian-fleabane (C9)
dwarf birch-shrubby cinquefoil-willow/brown moss (S1)
dwarf birch-shrubby cinquefoil/needlerush (S3)
willow/horsetail (S7)
willow/cinquefoil (S8)
mountain marigold-globeflower (H9)
water sedge-beaked sedge (H11)

SMALL MAMMAL ASSOCIATION V

Habitat:

This association occurs only in three upper subalpine and alpine vegetation types, on mesic or hygric sites derived from till or colluvium. The heather vole occurs at high density in two of these vegetation types and at a moderate density in the other type.

Dominant Species:

Heather vole	1.0

Definitive Species:

Heather vole	1.0

Additional Species:

Long-tailed vole	0.2	Northern bog lemming	0.2
Gapper's red-backed vole	0.1	Deer mouse	0.1
Western jumping mouse	0.1	Vagrant shrew	0.4
Yellow pine chipmunk	0.04	Least chipmunk	0.04
Masked shrew	0.02		

Remarks:

The capture rate of heather voles per 100 trap nights was 1.30 in O13, 0.57 in L5, and 0 in S9 (4 trap nights). This association and Association VI have a similarity value of 0.75.

Vegetation type correlates:

subalpine larch/heather (O13)
willow/timber oatgrass (S11)
heather-everlasting (L5)

SMALL MAMMAL ASSOCIATION VI

Habitat:

This association was found in only two upper subalpine vegetation types, on mesic to sub-hygric sites derived from till or colluvium.

Dominant Species:

Gapper's red-backed vole	1.1	Heather vole	1.0

Definitive Species:

Heather vole	1.0	Long-tailed vole	0.4

		Vagrant shrew	0.4
Least chipmunk	0.2	Yellow pine chipmunk	0.2

Additional Species:

Deer mouse	0.2	Western jumping mouse	0.2
Meadow vole	0.2	Masked shrew	0.1
Northern bog lemming	0.03		

Remarks:

Although the heather vole is definitive of this association as it is of Association 5, this one has relatively high numbers of Vagrant shrew, Long-tailed vole, and least and Yellow pine chipmunk. There were 1.1 and 0.9 heather voles, 0.55 and 0.28 vagrant shrews, and 0.11 and 0.23 Yellow pine chipmunks per 100 trap nights in C23 and O10 respectively.

Vegetation type correlates:

subalpine larch-subalpine fir/grouseberry-everlasting (C23)
Engelmann spruce-subalpine fir/heather (O10)

SMALL MAMMAL ASSOCIATION VII

Habitat:

This association occurs in subalpine shrub meadows. It has been recorded in only two vegetation types on mesic sites on alluvial, till or colluvial deposits. These shrub meadows are dominated by willows, dwarf birch and shrubby cinquefoil, with a lush herbaceous stratum.

Dominant Species:

Meadow vole	2.9	Long-tailed vole	2.3
Deer mouse	1.9		

Definitive Species:

Meadow vole	2.9	Long-tailed vole	2.3
Gapper's red-backed vole	0.4	Least chipmunk	0.3

Additional Species:

Heather vole	0.1	Western jumping mouse	0.1
Masked shrew	0.1		

Remarks:

This association, like Association IV, is dominated and defined by meadow vole. Here, however, Long-tailed vole and deer mouse are more abundant and the definitive species are different.

Vegetation type correlates:

willow–dwarf birch–shrubby cinquefoil (S10)
willow/hairy wild rye (S12)

6. ECOLOGICAL INTEGRATION

6.1. ECOSITE ACCOUNTS

A major objective of the inventory is to determine the habitat preferences of each species of wildlife and to present that information in a mappable format at a scale of 1:50,000. This section relates the habitat preferences to the mapping scheme.

The ecosite represents a classification concept based on landform, soils and vegetation. Thus the ecosite represents many elements of wildlife habitat and can also be related to maps. All wildlife sampling in this inventory was related to ecosites as well as vegetation. The results were analyzed by ecosite and then ranked to show the relative importance of each ecosite to wildlife.

It must be emphasized that these are relative rankings and not absolute. The uppermost rankings - high importance and very high importance - are equivalent to critical habitat in most cases. However, there will be instances where ecosites ranked as medium or low importance to a species are in fact critical during a brief period such as the breeding season, migration or rut. Our rankings are limited by the types of data provided by our sampling methods; to identify all critical habitats would in most cases require species-specific studies.

This section describes the relative importance of each ecosite to wildlife. The ecosite is described briefly at the beginning of each account as to its ecoregion, its geomorphic origin, and its typical vegetation. More detailed information is available in Volume II and the Map Legend accompanying the Map Supplement. Wildlife information is subdivided into sections on ungulates, carnivores, small mammals, birds, and reptiles and amphibians for convenience and consistency with our sample methods. The relative importance of the ecosite to each group as a whole is assessed. Where it is notably important to one or more species these are listed. Forage plants that showed utilization by ungulates on that ecosite are listed in the ungulate section, as well as the maximum snow depths recorded on winter track-count transects. Small mammal associations and breeding bird communities, described in sections 5.1 and 5.2 of this volume, are listed in the appropriate section for each ecosite.

Where a species is not effectively sampled by a quantitative method, we cannot rank its ecosite preference. Usually the only available records will be random observations, on the basis of which important ecosites are subjectively assessed.

AL1

Ecoregion: lower subalpine
Landform: alluvial fans
Vegetation: pine-spruce forest
occasional poplars

Ungulates:

This ecosite is highly important to ungulates year-round. Deer, moose and elk are the common ungulates, with the ecosite being especially important to deer and elk in summer. Major forage species recorded include willows, buffaloberry, grouseberry, labrador tea, prickly rose and lodgepole pine. Some AL1 tracts are important bedding areas for ungulates as they are well-forested and adjacent to open alluvial areas.

Carnivores:

This ecosite is highly important, particularly to wolf, coyote and cougar in summer and lynx and wolverine year-round.

Small mammals:

Associations 1 and 2

A moderate number of species occur here at moderate densities. Varying hare, Columbian ground squirrel, golden-mantled ground squirrel and western jumping mouse are common, and the bushy-tailed woodrat has been recorded.

Breeding birds:

Community 5

A high number of species occurs here at medium densities. This ecosite is highly important to the following species: Swainson's Thrush.

AL2

Ecoregion: lower subalpine
Landform: alluvial fans
Vegetation: spruce-fir forest
some pine and poplar

Ungulates:

AL2 is moderately important, being highly important to moose in summer, with forage use recorded on *Salix glauca* and other willows, dwarf birch, bracted honeysuckle and lodgepole pine. This ecosite is of low importance to other ungulates

Carnivores:

This ecosite is highly important to carnivores. While it is only moderately important for most species, all but fisher have been recorded here.

Small mammals:

Associations 1,2 and 3

Gapper's red-backed vole, Deer mouse and Meadow vole were the species caught most commonly on this ecosite. A high number of species is found here but only the red-backed vole, red squirrel and porcupine are relatively common.

Breeding birds:

Communities 5 and 8

A high number of species occurs here at high densities. This ecosite is highly important to the following species: Blackpoll Warbler.

AT1

Ecoregion: montane
Landform: glaciofluvial terraces
Vegetation: pine forest
some Douglas-fir

Ungulates:

AT1 is highly important to ungulates, especially deer and elk, at all times of year. These tracts in the Athabasca and Bow valleys combine mild winters with favourable conditions of forage and cover. Forage use was recorded on saskatoon, pinegrass, hairy wildrye, aspen, prickly rose and buffaloberry.

Carnivores:

This ecosite is highly important. Because of its importance to ungulates it is very highly important to wolf, coyote and cougar. Low snow accumulation in winter allows easy movement by both predators and prey. AT1 is of low importance to mustelids.

Small mammals:

Association 2
Deer mouse and Gapper's red-backed vole are the commenest species. The diversity and density of small mammals as well as the occurrence of bats make this ecosite important. It is very highly important to the survival of bats (big brown, little brown and long-legged) in the parks. Varying hares, red squirrels and deer mouse occur in high densities.

Breeding birds:

Community 5
A medium number of species occurs here at medium densities. This ecosite is highly important to the following species: Olive-sided Flycatcher, American Robin, Western Tanager, Dark-eyed Junco, and Yellow-rumped Warbler.

AT3

Ecoregion: montane
Landform: glaciofluvial terraces
Vegetation: dry grasslands
scattered pines and pine forest

Ungulates:

AT 3 is very highly important winter range, particularly for deer and elk, but only moderately important in summer. Mixtures of lodgepole pine forest and montane grassland comprise ideal winter range for elk especially in the lower Athabasca valley where this ecosite occurs most extensively.

Carnivores:

This ecosite is highly important to large carnivores primarily because of its importance to ungulates. It is of low importance to small carnivores.

Small mammals:

Association 1

A low number of species occurs here and only the deer mouse is found in high densities.

Breeding birds:

Communities 5 and 13
A low number of species occurs here at very high densities. This ecosite is highly important to the following species: Common Flicker, Black-billed Magpie, Common Crow, American Robin, Bohemian Waxwing, Warbling Vireo, Yellow-rumped Warbler, Red Crossbill, White-winged Crossbill, Vesper Sparrow, Dark-eyed Junco and Chipping Sparrow.

AZ1

Ecoregion: upper subalpine
Landform: glaciofluvial deposits
Vegetation: open spruce-fir forest

Ungulates:

This ecosite is highly important to ungulates, especially in summer to deer and, where they occur, to caribou. Snow depth on one winter transect was 1.2 m, too deep for winter travel by most ungulates.

Carnivores:

Overall, this ecosite is of low importance to carnivores.

Small mammals:

Associations 4 and 6
A high number of species occurs here but only the heather vole and, on some tracts, the yellow pine chipmunk occur in high densities. Water voles have been recorded on this ecosite.

Breeding birds:

Communities 7,10 and 17
A medium number of species occurs here at high densities. Species occurring here are probably the same as on TR1.

BK1

Ecoregion: lower subalpine
Landform: ridged glacial till deposits
Vegetation: dry areas: pine-spruce forest
wet areas: black spruce or birch-willow bogs

Ungulates:

BK1 is highly important to ungulates in summer, primarily to deer, moose and elk. Major forage series include willows (*Salix glauca* and *barrattiana*), rose, aspen, wild oat-grass, dwarf birch and saskatoon. Maximum recorded snow depth is 1.0 m, which is too deep for most ungulates except moose. Wet areas, especially, are highly important to moose in winter.

Carnivores:

This ecosite is very highly important, especially to large carnivores because of the high densities of deer, elk and moose in summer. There are also high densities of small mammals preyed on by small carnivores.

Small mammals:

Associations 1,2,3 and 4
A high number of species occurs here. Masked shrews, red squirrels, red-backed voles, meadow voles and western jumping mice are found in high densities.

Breeding birds:

Communities 5,6 and 9
A high number of species occurs here at high densities. This ecosite is highly important to the following species: Gray Jay, Townsend's Warbler, Yellow-rumped Warbler, and White-winged Crossbill.

Reptiles and Amphibians:

This ecosite is important to Western toad for foraging and breeding, where there are ponds.

BK4

Ecoregion: lower subalpine
Landform: ridged ice-contact drift deposits
Vegetation: dry areas: pine-spruce forest
wet areas: black spruce or birch-willow bogs

Ungulates:

Overall, this land system is highly important to ungulates, year-round. It is very highly important to elk in summer, and highly important to deer in summer and to moose in winter. In the wet depressions willows (*Salix myrtillifolia, glauca, farrae, planifolia* and *vestita*) are important forage species. Other important forage species are grouseberry, tall bilberry, rose and dwarf birch. Winter snow depths up to 0.7 m were recorded; these depths would restrict ungulate travel.

Carnivores:

This ecosite is very highly important for carnivores. High densities of lynx, marten, coyote, wolf and cougar occur here.

Small mammals:

Associations 1,2,3, and 4
A moderate number of species occures here, and high densities of varying hares and red-backed voles. Flying squirrels and bushy-tailed wood rats have been recorded here.

Breeding birds:

Communities 5,6 and 9
A high number of species occurs here at high densities. This ecosite is highly important to the following species: Gray Jay, Swainson's Thrush, Golden-crowned Kinglet, Yellow-rumped Warbler, Blackpoll Warbler, Northern Waterthrush, and White-winged Crossbill. Golden-crowned Kinglet is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

Reptiles and Amphibians:

This ecosite is an important breeding habitat for Spotted frog and Western toad.

BK6

Ecoregion: lower subalpine
Landform: ridged ice-contact drift deposits
Vegetation: dry areas: spruce-fir forest
wet areas: black spruce or birch-willow bogs

Ungulates:

Despite the occurrence of every species of ungulate on this ecosite, its overall importance is medium in summer and low in winter. Nevertheless the ecosite is highly important in winter to moose, which forage in the wet shrublands. Much of this ecosite is covered in mature spruce-fir forest that offers little forage to ungulates. Snow depths of up to 1.1m were recorded; these would further limit ungulate occurence here

Carnivores:

Like BK 4, this ecosite is very highly important for carnivores, especially coyote, marten and lynx.

Small mammals:

Associations 1,2,3 and 4
High densities of varying hares and red-backed voles are found here but there is only a moderate number of species of small mammals.

Breeding birds:

Communities 6,8, and 9
A medium number of species occurs here at medium densities. This ecosite is highly important to the following species: Gray Jay and White-winged Crossbill.

BP1

Ecoregion: upper subalpine
Landform: colluvial landslide deposits
Vegetation: open coniferous forest
some dryas patches and exposed rocks

Ungulates:

This ecosite is of low important to ungulates year-round although goats occur in high densities in some tracts of this ecosite in early summer. Some willows (*Salix glauca*) are eaten, but much of the ground cover is unsuitable forage. Potential deep snow restricts ungulate travel.

Carnivores:

Overall, this ecosite is of low importance to carnivores. However its importance to marten and weasels is high.

Small mammals:

Association 1
There is a moderate number of species here. Numbers of dusky shrews, pikas, Columbian ground squirrels, northern bog lemmings and long-tailed voles are high.

Breeding birds:

Community 7

A low number of species occurs here at low densities.

BP2

Ecoregion: upper subalpine
Landform: colluvial landslide deposits
Vegetation: closed or open spruce-fir forest
some exposed rocks

Ungulates:

This ecosite is very highly important to goats especially in winter. Where tracts occur adjacent to steep terrain goats seek cover here during winter storms and forage in early summer. Forage species on which use was recorded include willows (*Salix glauca, arctica, vestita*), bluegrasses and buffaloberry.

Carnivores:

Like BP1, the importance of this ecosite to carnivores is low.

Small mammals:

Associations 3 and 6
A low number of species occurs here. The least chipmunk and heather vole occur in high densities.

Breeding birds:

Communities 7 and 8
A low number of species occurs here at low densities. This ecosite is highly important to the following species: Clark's Nutcracker, Winter Wren and Hermit Thrush.

BS1

Ecoregion: alpine
Landform: colluvial slopes
Vegetation: dryas tundra

Ungulates:

BS1 is highly important to ungulates, particularly as winter range for sheep and goats. This ecosite is usually wind-blown and snow-free in winter making it ideal for ungulates. However the dry environment supports only sparse forage, with use recorded on willows,mountain sorrel, alpine bluegrass and sedges.

Carnivores:

The importance of this ecosite to carnivores is low. Few carnivores occur on alpine ecosites.

Small mammals:

Association 1
Trapping effort was inadequate on this ecosite but observations in related ecosites (RD1, TK1) and associated vegetation types (H1, L5) suggest that this ecosite may be moderately important.

Breeding birds:

Community 18
A low number of species occurs here at low densities. This ecosite is highly

important to the following species: White-tailed Ptarmigan, Horned Lark and Water Pipit.

BV1

Ecoregion: lower subalpine
Landform: glaciofluvial terraces
Vegetation: pine-spruce forest

Ungulates:

This ecosite is moderately important to deer, elk and moose primarily because of its low elevation and association with other more open habitats. Although snow up to 0.7m deep was recorded, most winter transects were over less then 0.3 m of snow.

Carnivores:

The importance of this ecosite to carnivores is high. Although only coyote and lynx are expected in high densities, most other species occur here.

Small mammals:

Association 2
A moderate number of species is found here. The varying hare, red squirrel, meadow vole and porcupine occur in high densities.

Breeding birds:

Community 5
A medium number of species occurs here at high densities. This ecosite is highly important to the following species: Swainson's Thrush, Yellow-rumped Warbler and White-winged Crossbill.

BV2

Ecoregion: lower subalpine
Landform: glaciofluvial terraces
Vegetation: moist pine-spruce or spruce-fir forest

Ungulates:

This ecosite is of low importance to ungulates, despite the low snow accumulation. The dense forest on this ecosite offers little forage for ungulates.

Carnivores:

The importance of this ecosite to carnivores is moderate. The ecosite is highly important to marten, while it is of low to moderate importance to other carnivores.

Small mammals:

Associations 2 and 3
While there is a high number of species here only the red-backed vole occurs in high densities. The bushy-tailed wood rat has been recorded in this ecosite.

Breeding birds:

Community 5
A low number of species occurs here at high densities. This ecosite is highly

important to the following species: Northern Three-toed Woodpecker, Mountain Chickadee, Swainson's Thrush and Yellow-rumped Warbler.

BV3

Ecoregion: lower subalpine
Landform: glaciofluvial terraces
Vegetation: spruce-fir forest

Ungulates:
Like BV2, this ecosite is of low importance to ungulates.

Carnivores:
The importance of this ecosite to carnivores is low.

Small mammals:
Associations 2 and 3
A low number of species is found on this ecosite. Masked shrews, red-backed voles and western jumping mice occur at high densities.

Breeding birds:
Community 8
A low number of species occurs here at low densities. This ecosite is highly important to the following species: Winter Wren and Golden-crowned Kinglet. Golden-crowned Kinglet is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

BY1

Ecoregion: lower subalpine
Landform: glacial till slopes
Vegetation: spruce-fir forest

Ungulates:
This ecosite is of low importance to ungulates because of the prevalence of spruce-fir forest and deep winter snow (up to 1.2 m).

Carnivores:
This ecosite is moderately important to most species of carnivores.

Small mammals:
Associations 2 and 3
A moderate number of species is found here. Red-backed voles and porcupines occur at high densities.

Breeding birds:
Community 8
A high number of species occurs here at high densities. This ecosite is highly important to the following species: Brown Creeper, Hermit Thrush and Pine Siskin.

BY2

Ecoregion: lower subalpine
Landform: glacial till slopes
Vegetation: spruce-fir forest

Ungulates:
This ecosite is moderately important to ungulates year-round. The major difference between the importance of this ecosite and that of BY1 and BY4 is the presence of caribou on tracts of this ecosite in Jasper. Snow depths on our transects were usually less than 0.8 m, which is shallower than those recoreded on BY 1. Browsing is heavier on this ecosite than on BY 1 and BY4, most notably on dwarf birch and willows.

Carnivores:
BY 2 is highly important to carnivores. Although it is highly important only to lynx, it is moderately important to every other species but mink.

Small mammals:
Associations 1 and 3
A moderate number of species is found on this ecosite. There are high densities of varying hares, red-backed voles and porcupines.

Breeding birds:
Community 8
A high number of species occurs here at low densities. This ecosite is highly important to the following species: Brown Creeper.

BY4

Ecoregion: lower subalpine
Landform: ice-contact drift deposits on valley slopes
Vegetation: spruce-fir forest

Ungulates:
BY4 is of low importance to ungulates. Mature spruce forest, sparse browse and deep snow make it less attractive to ungulates than other subalpine ecosites.

Carnivores:
This ecosite is highly important, especially to marten and lynx. It is only moderately important to the larger carnivores.

Small mammals:
Associations 2 and 3
A low number of species occurs on this ecosite and only the varying hare occurs at high densities.

Breeding birds:
Community 8
A medium number of species occurs here at high densities. This ecosite is highly important to the following species: Evening Grosbeak and Pine Siskin.

BZ1

Ecoregion: lower subalpine
Landform: rock residuum slopes
Vegetation: spruce-fir forest

Ungulates:

This ecosite is of moderate importance in winter and low importance in summer. All ungulates except caribou were recorded on this ecosite, with snow depths not being recorded deeper than .4m. Forage species recorded were wild rose and willows (*Salix glauca*).

Carnivores:

This ecosite is moderately important to carnivores including coyote, wolf and cougar. It is highly important to weasel, likely because it supports a high density of small mammals.

Small mammals:

Associations 1 and 3
Few species occur here. Only the deer mouse and red-backed vole occur at high densities.

Breeding birds:

Community 8
A low number of species occurs here at low densities. This ecosite is highly important to the following species: Gray Jay and Yellow-rumped Warbler.

BZ2

Ecoregion: lower subalpine
Landform: rock residuum slopes
Vegetation: pine-spruce forest

Ungulates:

This ecosite has similar year-round importance for ungulates to BZ1; moderate in autumn and winter, and low in summer. Caribou, deer and moose were the only species recorded on pellet count surveys; the ecosite is highly important to deer and very highly important to moose in autumn and winter. As in BZ1, snow accumulation is only moderate.

Carnivores:

This ecosite is of low importance to carnivores. Few species have been recorded here. A high track index was recorded for marten.

Small mammals:

Association 2
A moderate number of species occurs on this ecosite but only the red-backed vole is found at high densities.

Breeding birds:

Community 5
A low number of species occurs here at medium densities. This ecosite is highly important to the following species: Yellow-rumped Warbler> and Dark-eyed Junco.

CA1

Ecoregion: lower subalpine
Landform: ridged glacial till deposits

Vegetation: dry areas: spruce-fir forest
wet areas: spruce and birch-willow bogs

Ungulates:
This ecosite is moderately important to ungulates in summer, primarily to deer and elk. The only forage species that was eaten on our plots was a willow (*Salix barclayii*). Up to 1 m of snow was recorded on this ecosite, and its low importance in winter may be largely due to deep snow.

Carnivores:
The high importance of this ecosite is because of its high importance to marten, weasel and lynx, and of the variety of other species that occur here.

Small mammals:
Associations 2,3 and 4
A moderate number of species occurs here. There are high densities of masked shrews, varying hares and red-backed voles.

Breeding birds:
Communities 6,8 and 9
A medium number of species occurs here at high densities. This ecosite is highly important to the following species: Boreal Chickadee, Varied Thrush, Swainson's Thrush, Yellow-rumped Warbler, Townsend's Warbler, Pine Siskin and Dark-eyed Junco.

CA2

Ecoregion: lower subalpine
Landform: glacial till deposits
Vegetation: spruce-fir forest

Ungulates:
This ecosite is of low importance to ungulates year-round.

Carnivores:
Like CA 1, this ecosite is highly important to carnivores. It is especially important to marten and lynx.

Small mammals:
Associations 2 and 3
A high number of species occurs on this ecosite. Snowshoe hares and red-backed voles are found in high densities.

Breeding birds:
Community 8
A medium number of species occurs here at medium densities.

CA4

Ecoregion: lower subalpine
Landform: glacial till deposits
Vegetation: pine-spruce forest

Ungulates:

This ecosite is moderately important year-round to ungulates, especially moose. Snow depths were never recorded over .8 m and often were less than 0.4m. Wiliows are the main forage species (*S. farrae, glauca, vestita, barclayii, candida* and *scouleriana*).

Carnivores:
Like CA1 and 2, CA4 is highly important to carnivores, especially marten.

Small mammals:
Association 3
This ecosite supports a moderate number of species and high densities of deer mice and red-backed voles.

Breeding birds:
Community 5
A low number of species occurs here at low densities. This ecosite is highly important to the following species: Townsend's Warbler.

CN1

Ecoregion: upper subalpine
Landform: alluvial fans
Vegetation: birch-willow meadows

Ungulates:
This ecosite is highly important to ungulates year-round. It is most important to elk, mountain goat and bighorn sheep. The shrub meadows include numerous forage plants. Snow accummulation was recorded up to 1.1m although less than 0.8 m was more usual. This deep snow would exclude large mammals in winter.

Carnivores:
This ecosite is of low importance to carnivores.

Small mammals:
Association 7
The diversity and density of small mammals as well as the occurrence of the water vole make this upper subalpine ecosite highly important for small mammals. This ecosite supports a high number of species and high densities of Columbian ground squirrels, deer mice, heather voles, meadow voles and long-tailed voles.

Breeding birds:
Community 7
A medium number of species occurs here at low densities. This ecosite is highly important to the following species: Olive-sided Flycatcher, Wilson's Warbler and White-crowned Sparrow.

CP1

Ecoregion: upper subalpine
Landform: rock residuum slopes
Vegetation: spruce-fir forest

Ungulates:
This rocky ecosite is moderately important to ungulates year-round, especially to

bighorn sheep and caribou where they occur. Deep snow (measured to 0.8 m) precludes extensive winter use by most ungulates.

Carnivores:
This ecosite is moderately important to carnivores. It is highly important to weasels.

Small mammals:
Associations 3 and 6
This ecosite supports a moderate number of species and very high densities of heather voles.

Breeding birds:
Communities 7 and 8
A low number of species occurs here at medium densities. This ecosite is highly important to the following species: Gray Jay.

CV1

Ecoregion: lower subalpine
Landform: ridged glacial till deposits
Vegetation: dry areas: spruce-fir forest
wet areas: spruce or birch-willow bog

Ungulates:
This ecosite is moderately important in summer, especially to moose. Browse species on which use was recorded are dwarf birch, shrubby cinquefoil and willow (*S. barrattiana, farrae, glauca* and *vestita*). Snow depths up to 1.0 m preclude extensive winter use by ungulates other than moose. All species but bighorn sheep have been recorded on this ecosite.

Carnivores:
This ecosite is very highly important to carnivores. It is highly important to coyote, marten, weasel and wolverine, and moderately important to wolf, cougar and lynx where these occur.

Small mammals:
Associations 2,3 and 4
A high number of species occurs here. There are high densities of yellow pine chipmunks, meadow voles and porcupines.

Breeding birds:
Communities 5,6 and 9
A high number of species occurs here at high densities. This ecosite is highly important to the following species:, Varied Thrush, Hermit Thrush, Yellow-rumped Warbler, Townsend's Warbler and Pine Siskin.

Reptiles and Amphibians:
This ecosite includes important breeding habitat for Wood frog, Spotted frog and Western toad.

DV1

Ecoregion: montane
Landform: sand and silt dunes
Vegetation: dry grassland with juniper and shrubs
some white spruce and poplar clumps

Ungulates:
These montane grasslands are very highly important to ungulates in winter, primarily to deer and elk, although some rocky areas in the lower Athabasca valley are important bighorn sheep range. Forage use was recorded on needle grass, wheatgrass sedges and other species. These areas receive little snow and are warm and wind-blown. Consequently they are bare most of the winter and snow rarely exceeds 0.3 m deep.

Carnivores:
This ecosite is highly important to carnivores especially wolf, coyote, cougar and weasel. It is most important in winter when ungulates concentrate here. There are several records of coyote and wolf dens on DV ecosites.

Small mammals:
Association 1
There is few species here and only the deer mouse occurs in high densities.

Breeding birds:
Community 4
A low number of species occurs here at medium densities. This ecosite is highly important to the following species: Black-billed Magpie and White-crowned Sparrow.

DV2

Ecoregion: montane
Landform: sand and silt dunes
Vegetation: white spruce forest
some dry grassland

Ungulates:
Like DV1, this ecosite is very highly important in winter, but only moderately so in summer. Deer and elk are almost the only species here. Like DV1 there is little snow accummulation, although drifted snow is more common. Forage species on which use was recorded include wild rose, willows (*S. scouleriana*), shrubby cinquefoil, silverberry and saskatoon-berry.

Carnivores:
This ecosite is highly important, especially to wolf, coyote and cougar in winter. There are several records of coyote and wolf dens on DV ecosites.

Small mammals:
Association 1
A low number of species occurs on this ecosite and only the ubiquitous deer mouse occurs in high densities.

Breeding birds:

Community 5

A low number of species occurs here at high densities. This ecosite is highly important to the following species: Northern Three-toed Woodpecker, Gray Jay, American Robin, Yellow-rumped Warbler, Dark-eyed Junco and Chipping Sparrow. The uncommon White-throated Sparrow has nested here.

EF1

Ecoregion: alpine
Landform: glacial till slopes and ridges
Vegetation: heath meadows

Ungulates:

This ecosite is of low importance in winter but is moderately important in summer especially to mountain goat and, where they occur, caribou. In winter snow up to 0.8 m limits ungulates use. In summer Rocky Mountain fescue and sedges (*Carex nardina* and *scirpoidea*) are eaten.

Carnivores:

The importance of this ecosite to carnivores is low especially in winter when there is deep snow.

Small mammals:

Association 5

The density of small mammals as well as the occurrence of the water vole make this ecosite highly important for small mammals. Although the number of species found here is moderate, there are high densities of dusky shrews, hoary marmots, Columbian ground squirrels, golden-mantled ground squirrels and heather voles.

Breeding birds:

Community 17

A low number of species occurs here at low densities. Species of birds found here are probably the same as on other alpine ecosites like JN1.

EG1

Ecoregion: upper subalpine
Landform: glacial till deposits
Vegetation: spruce-fir forest

Ungulates:

In summer, this ecosite is moderately important to ungulates, especially moose and elk. Maximum recorded snow depth is 1.5 m, a depth which would limit ungulate movement. Forage species include willows (*S. glauca* and *vestita*), dwarf birch, false dandelion, and grouseberry.

Carnivores:

This ecosite is highly important, especially to marten. It is moderately important to the larger carnivores.

Small mammals:

Associations 2,3 and 6

This ecosite supports a moderate number of species. High densities of varying hares, golden-mantled ground squirrels, red-backed voles and porcupines occur

on this ecosite. Muskrats have been recorded here, although they rarely occur at so high an elevation.

Breeding birds:
Communities 7 and 8
A high number of species occurs here at low densities. This ecosite is highly important to the following species: Red Crossbill.

EG2

Ecoregion: upper subalpine
Landform: glacial till deposits
Vegetation: larch-fir forest

Ungulates:
This ecosite is highly important, especially to moose in winter and elk in summer. Deep snow (maximum recorded depth is 1.5 m) limits movement in winter by ungulates. Available information does not explain why EG2 is more heavily used than other ecosites in the EG ecosection.

Carnivores:
Like EG1, this ecosite is highly important, especially to marten. Large carnivores can be expected most of the year except in winter, when snow is deep and prey scarce.

Small mammals:
Associations 5 and 6
This ecosite supports few species, and high densities of heather voles.

Breeding birds:
Communities 7 and 8
A highnumber of species occurs here at low densities.

EG3

Ecoregion: upper subalpine
Landform: ridged glacial till deposits
Vegetation: dry areas: spruce-fir or larch-fir forest
wet areas: herb meadows and open spruce-fir forest

Ungulates:
This ecosite is of low importance to ungulates year-round. Deep winter snow (up to 1.5m) and heavy forest cover contribute to the scarcity of ungulates.

Carnivores:
This ecosite is moderately important to carnivores, being highly important to marten. Wolf and coyote may only be expected in summer.

Small mammals:
Associations 3,5 and 6
The diversity and density of small mammals as well as the occurrence of water voles and bushy-tailed wood rats make this upper subalpine ecosite important for

small mammals. The ecosite supports a high number of species and high densities of bog lemmings.

Breeding birds:

Communities 7,8 and 17
A medium number of species occurs here at medium densities. This ecosite is highly important to the following species: Winter Wren, Ruby-crowned Kinglet, Gray-crowned Rosy Finch, Golden-crowned Sparrow and Fox Sparrow.

EG4

Ecoregion: upper subalpine
Landform: glacial till deposits
Vegetation: open timberline forest with heath meadows

Ungulates:

Although this ecosite is of low importance to ungulates overall, it is important to bighorn sheep adjacent to steep slopes and to caribou within their range. Deep snow (recorded up to 1.0 m) precludes extensive winter use. Willows (*S. glauca* and *vestita*) and herbs were utilized on this ecosite.

Carnivores:

The importance of this ecosite is low. While six species were recorded, all were at low to moderate densities.

Small mammals:

Associations 5 and 6
The occurrence of the very rare water shrew and the uncommon water vole make this ecosite highly important for small mammals. This ecosite is one of only four where the water shrew was recorded during this project. There is a moderate number of other species and high densities of heather voles.

Breeding birds:

Communities 7 and 17
A medium number of species occurs here at medium densities. This ecosite is highly important to the following species: Common Raven, Clark's Nutcracker, Mountain Bluebird, Townsend's Solitaire, American Redstart, Pine Siskin and White-winged Crossbill. American Kestrel and Mountain Bluebird are listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

EN1

Ecoregion: upper subalpine
Landform: colluvial slopes
Vegetation: spruce-fir forest

Ungulates:

This steep ecosite is moderately important to ungulates, especially to mountain goats in autumn and winter. It provides escape terraine, low snow accumulation because of the steep slope, and cover in forested areas.

Carnivores:

This ecosite is of low importance, likely because of the low densities of prey.

Small mammals:

Associations 2,3 and 4
A high number of species occurs on this ecosite but only at moderate or low densities.

Breeding birds:

Communities 7 and 8
A low number of species occurs here at low densities.

EN2

Ecoregion: upper subalpine
Landform: colluvial slopes with active avalanching
Vegetation: avalanche shrubbery and meadows
some spruce-fir forest

Ungulates:

This steep ecosite is moderately important to ungulates overall, and very highly important to mountain goats. The steep, rocky portions provide escape terrain, while the forested areas provides winter cover and forage. Fescues, sedge (*Carex pyrenaica*), Baltic rush, bluegrasses (*Poa alpina* and *artica* and willows (*S. artica, barrattiana, glauca* and *vestita*) are all eaten here. Snow accumulation was not measured.

Carnivores:

This ecosite is of low importance to carnivores, likely because of the low densities of prey.

Small mammals:

Associations 1 and 6
This ecosite supports few species. Meadow voles and western jumping mice are found in high densities.

Breeding birds:

Communities 7,10,12 and 16
A medium number of species occurs here at low densities. This ecosite is highly important to the following species: Townsend's Solitaire, Brewer's Sparrow and Golden-crowned Sparrow.

EN3

Ecoregion: upper subalpine
Landform: colluvial slopes
Vegetation: open coniferous forest
much exposed rock and small shrub tangles

Ungulates:

Like the other EN ecosites, EN3 is moderately important to ungulates. While it is less important to goats than EN1 or EN2, it is used more by deer, elk and moose. Forage species are similar to EN2 but use is lighter. Snow accumulation is low.

Carnivores:

This ecosite if of low importance to carnivores likely because of the low

densities of prey.

Small mammals:

Associations 1 and 6
Few species occur here, and only the varying hare is found in high densities.

Breeding birds:

Community 7
A low number of species occurs here at low densities. This ecosite is highly important to the following species: Townsend's Solitaire and Gray-crowned Rosy Finch.

FR1

Ecoregion: montane
Landform: alluvial fans
Vegetation: pine-spruce forest

Ungulates:

This ecosite is highly important to ungulates, especially deer, moose and elk in winter. The high pellet counts on this ecosite likely result from its use as a bedding area by ungulates foraging in nearby, more open ecosites. However moderate snow accumulation (0.1m) and forage species such as balsam poplar, aspen, wild rose and willow (*Salix candida*) increase the importance of this exosite.

Carnivores:

This ecosite is highly important, especially to wolf, coyote, cougar and lynx, because of the high density of prey species, especially in winter. Other carnivores are relatively scarce.

Small mammals:

Associations 1 and 2
The diversity and density of small mammals as well as the occurrence of the little brown bat and the bushy-tailed wood rat make this ecosite important for small mammals. It supports a high number of species and high densities of varying hares, red squirrels, beavers, deer mice, red-backed voles and heather voles.

Breeding birds:

Community 5
A high number of species occurs here at high densities. This ecosite is highly important to the following species: Cooper's Hawk, Least Flycatcher, Red-breasted Nuthatch, Swainson's Thrush, Warbling Vireo and Townsend's Warbler. Cooper's Hawk is listed on the 1981 Blue List of the National Audubon Society (Tate 1981)..

Reptiles and Amphibians:

The uncommon Wandering garter snake has been recorded regularly at the Banff Cave and Basin on the FR1 ecosite.

FV1

Ecoregion: lower subalpine
Landform: colluvial slopes with active avalanching
Vegetation: avalanche shrubbery and meadows
some spruce-fir forest

Ungulates:

This ecosite is of low importance to ungulates. Snow depths of 1.1 m were recorded. Farther east it is moderately important. Importance to ungulates is highest on active avalanche slopes where willows (*S. glauca* and *lasiandra*) are browsed by moose.

Carnivores:

This ecosite is of moderate importance, being highly important to weasel and wolverine.

Small mammals:

Associations 2 and 3
This ecosite supports a high number of species and high densities of masked shrews, pikas, golden-mantled ground squirrels and western jumping mice.

Breeding birds:

Communities 8,10,11,12 and 16
A medium number of species occurs here at high densities. This ecosite is highly important to the following species. Rufous Hummingbird, Alder Flycatcher, Dusky Flycatcher, Hermit Thrush, Warbling Vireo, Orange-crowned Warbler, Yellow Warbler, Yellow-rumped Warbler, Townsend's Warbler, Macgillivray's Warbler, Wilson's Warbler, American Redstart and Fox Sparrow. Yellow Warbler is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

FV2

Ecoregion: lower subalpine
Landform: colluvial slopes
Vegetation: spruce-fir forest

Ungulates:

This ecosite is moderately important. All ungulate species occur on this ecosite but only moose use it intensively in the autumn and winter. Snow depth and forage use were not measured.

Carnivores:

The importance of this ecosite to carnivores is low. It is moderately important to wolf, coyote, cougar and lynx.

Small mammals:

Associations 2 and 3
A high number of species is found here, but only the red-backed vole occurs in high densities.

Breeding birds:

Community 8
A low number of species occurs here at medium densities. This ecosite is highly important to the following species: Winter Wren and Golden-crowned Kinglet. Golden-crowned Kinglet is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

GA1

Ecoregion: montane
Landform: colluvial landslide deposits
Vegetation: dry pine or Douglas-fir forest
some aspen stands

Ungulates:

This ecosite is highly important year-round, being very highly important to deer year-round and to elk in summer. The varied topography provides a mosaic of open south-facing slopes with coniferous cover. There is low snow accumulation (<0.3 m) and relatively warm winters, especially on south exposures.

Carnivores:

This ecosite is highly important to carnivores especially wolf, coyote and cougar in summer.

Small mammals:

Associations 1 and 2
A low number of species occurs here. Flying squirrels have been recorded here.

Breeding birds:

Communities 3 and 5
A high number of species occurs here at high densities. This ecosite is highly important to the following species: Pileated Woodpecker, Hairy Woodpecker, Northern Three-toed Woodpecker, Mountain Chickadee, Red-breasted Nuthatch, American Robin, Solitary Vireo, Warbling Vireo, Tennessee Warbler, Yellow-rumped Warbler, Townsend's Warbler, Red Crossbill, White-winged Crossbill and Dark-eyed Junco.

GT1

Ecoregion: lower subalpine
Landform: glacial till slopes
Vegetation: open, dry coniferous forest
some pine and aspen stands

Ungulates:

This ecosite is highly important to ungulates year-long. All species but caribou were recorded here, with elk and bighorn sheep using the ecositei most heavily. Forage species include wild rose, willows (*S. glauca* and *vestita*), aspen, Rocky Mountain fescue and hairy wildrye. In winter, snow depths were recorded to 0.7m.

Carnivores:

This ecosite is very highly important especially to wolf, coyote, and cougar. It is moderately important to marten, lynx and wolverine.

Small mammals:

Association 1
High densities of masked shrews and heather voles and a moderate number of species are found on this ecosite.

Breeding birds:

Communities 4,5 and 7

A low number of species occurs here at low densities. This ecosite is highly important to the following species: Olive-sided Flycatcher, Townsend's Solitaire and Yellow-rumped Warbler.

GT2

Ecoregion: lower subalpine
Landform: gullied glacial till deposits
Vegetation: dry slopes: pine forest
mesic slopes: grassland and bearberry patches

Ungulates:
This ecosite is very highly important to ungulates all year round. The southerly slopes have few trees but various palatable forage species. Elk and deer are commonest but bighorn sheep and mountain goat occur on some tracts especially adjacent to rocky terrain. In winter, snow depths were recorded to 0.7 m, a depth which would preclude most ungulate occurrence.

Carnivores:
This ecosite is very highly important to carnivores especially wolf, coyote, cougar and lynx. It is of low importance to marten, weasel and wolverine.

Small mammals:
Associations 1 and 2
This ecosite supports a high number of species as well as high densities of varying hares, least chipmunks, Columbian ground squirrels, deer mice, northern bog lemmings and meadow voles.

Breeding birds:
Communities 4,5 and 16
A medium number of species occurs here at medium densities. This ecosite is highly important to the following species: Townsend's Solitaire.

HC1

Ecoregion: lower subalpine
Landform: alluvial floodplain deposits
Vegetation: open spruce and birch-willow bogs
some ponds and springs

Ungulates:
Overall this ecosite is of moderate importance to ungulates; however it is highly important to moose and caribou where they occur. The shrublands provide ample forage including willows (*Salix barrattiana, farrae, glauca, myrtillifolia* and *vestita*) shrubby cinquefoil, and dwarf birch. In winter, snow depths were recorded to 0.9 m.

Carnivores:
This ecosite is highly important, especially to wolverine in winter and wolf and coyote in summer. It is moderately important to most of the other carnivores

Small mammals:
Associations 3 and 4

A high number of species and high densities of masked shrews, dusky shrews and western jumping mice occur on this ecosite. The rare water shrew has been recorded here and in only three other ecosites.

Breeding birds:

Communities 6,8 and 9

A high number of species occurs here at high densities. This ecosite is highly important to the following species: Tree Swallow, Ruby-crowned Kinglet, Dark-eyed Junco and Yellow-rumped Warbler.

Reptiles and Amphibians:

This ecosite includes important breeding habitat for Wood frog and Western toad.

HC1

Ecoregion: lower subalpine
Landform: alluvial floodplain deposits
Vegetation: sedge meadow
some willows

Ungulates:

This ecosite is of low importance to ungulates. Elk graze these meadows in all seasons. The intensity of winter use is dependent on snow depth,which has been recorded as deep as 0.7 m.

Carnivores:

This ecosite is moderately important to mustelid species but of low importance to other carnivores.

Small mammals:

Association 4

A few species occur here at low to moderate densities.

Breeding birds:

Community 14

A medium number of species occurs here at high densities. This ecosite is highly important to the following species: Killdeer, Common Snipe, Red-winged Blackbird and Savannah Sparrow.

Reptiles and Amphibians:

This ecosite is an important breeding habitat for spotted frog and western toad.

HC4

Ecoregion: lower subalpine
Landform: alluvial floodplains
Vegetation: birch-willow meadows with sedge

meadows and ponds
some clumps of spruce and tall shrubs

Ungulates:

This ecosite is highly important to ungulates, especially moose, elk and caribou. Forage species on which use was recorded were dwarf birch, alder, sedge (*Carex aquatilis* and *C. rostrata*), tufted hairgrass, timothy, alpine bluegrass, shrubby cinquefoil and willows (*Salix barrattiana, barclayii, farrae, glauca* and *vestita*). Winter use of this ecosite varies depending on snow depth, which was recorded as deep as 0.9 m.

Carnivores:

This ecosite is highly important to carnivores, particularly wolf, coyote, cougar and weasels. It is moderately important to marten and lynx.

Small mammals:

Association 4 and 5
The high diversity and density of small mammals make this ecosite highly important. Beaver, northern bog lemming, meadow vole and porcupine are common here. Muskrat and Richardson's water vole are present in some tracts.

Breeding birds:

Communities 9, 10 and 11

A very high number of species occurs here at high densities. This ecosite is highly important to the following species: Solitary Sandpiper, Greater Yellowlegs, Willow Flycatcher, Red-winged Blackbird, Brewer's Blackbird, Tennessee Warbler, Northern Waterthrush, Northern Yellowthroat, Wilson's Warbler, Savannah Sparrow, Leconte's Sparrow, White-crowned Sparrow, Lincoln's Sparrow and Song Sparrow. Willow Flycatcher is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

Reptiles and Amphibians:

This ecosite is an important breeding habitat for wood and spotted frogs and western toad.

HD1

Ecoregion: montane
Landform: alluvial fans
Vegetation: aspen forest
some balsam poplar and spruce, open meadows

Ungulates:

This ecosite is highly important to ungulates in winter, especially to elk and deer. Snow accumulation is low, with a maximum recorded depth of 0.6 m. Forage species on which use has been recorded are paintbrush, hairy wildrye, *Hedysarum mackenzii*, timothy, balsam poplar, aspen, prickly rose, buffaloberry, spiraea and dandelion.

Carnivores:

This ecosite is highly important, notably to coyote, wolf, cougar and marten. It is moderately important to lynx.

Small mammals:
Association 1

A high number of species including flying squirrel, occur here. High densities of Columbian ground squirrel, red squirrel and meadow vole were recorded.

Breeding birds:
Community 1

A very high number of species occurs here at high densities. This ecosite is highly important to the following species: Ruffed Grouse, Common Flicker, Yellow Bellied Sapsucker, Downy Woodpecker, Least Flycatcher, Hammond's Flycatcher, Western Wood Peewee, American Robin, Common Starling, Red-eyed Vireo, Warbling Vireo, Orange-crowned Warbler, Pine Siskin, Red Crossbill and Clay-coloured Sparrow.

Reptiles and Amphibians:

Where ponds occur on this ecosite they are important breeding sites for wood frog and long-toed salamander.

HD2

Ecoregion: montane
Landform: alluvial fans
Vegetation: open spruce forest

Ungulates:
This ecosite is highly important to ungulates year-round, especially to elk and deer. The open forest provides both forage and cover. Snow accumulation is low, the maximum recorded being 0.5 m. Forage species on which use was recorded include river alder, saskatoon, bunchberry, silverberry, *Hedysarum mackenzii*, balsam poplar, aspen, prickly rose, buffaloberry and willows (*Salix barclayii* and *glauca*).

Carnivores:
This ecosite is highly important to wolf, coyote, cougar and lynx.

Small mammals:
Association 1

A high number of species are present, including high densities of masked shrew, varying hare, red squirrel, and deer mouse. The only record of northern pocket gopher in Banff and Jasper was in a tract of this ecosite at the Ghost Lakes area in Banff.

Breeding birds:

Community 4

A high number of species occurs here at high densities. This ecosite is highly important to the following species: Swainson's Thrush, Ruby-crowned Kinglet, Yellow-rumped Warbler and Brown-headed Cowbird.

Reptiles and Amphibians:
The uncommon wandering garter snake was recorded twice on this ecosite, once in each park.

HD3

Ecoregion: montane
Landform: alluvial fans
Vegetation: spruce forest
occasional Douglas-fir

Ungulates:
This ecosite is highly important to ungulates in autumn and winter but only of moderate importance in summer. It is most heavily used by deer year-round and moose in winter. Forage plants on which use was recorded were river alder, red-osier dogwood, silverberry, *Hedysarum mackenzii*, aspen, prickly rose, willows (*Salix farrae, glauca* and *scouleriana*), needle grass and snowberry.

Carnivores:
This ecosite is highly important to wolf, coyote, cougar and lynx.

Small mammals:
Association 1 and 2

A moderate number of species occurs here. Varying hare, least chipmunk and deer mouse occur at high densities and the ecosite is used by feeding bats.

Breeding birds:
Community 5

A medium number of species occurs here at high densities. This ecosite is highly important to the following species: Pileated Woodpecker, Yellow Bellied Sapsucker, Common Starling, Warbling Vireo, Yellow-rumped Warbler, Blackpoll Warbler and Dark-eyed Junco.

HD4

Ecoregion: montane
Landform: alluvial fans
Vegetation: dry grassland
scattered pines and clumps of pines

Ungulates:
These grasslands are highly important to ungulates , especially deer and elk, all year. Snow accumulation is low, the maximum recorded being 0.4m. Cover and forage are abundant. Use was recorded on wheatgrass (*Agropyron inerme*),

cut-leaved anenome, junegrass, aspen, bluegrasses and prickly rose.

Carnivores:
This ecosite is highly important to wolf and coyote.

Small mammals:
Association 1

A moderate number of species occurs here, including the little brown bat. There are high densities of red squirrel and deer mouse.

Breeding birds:
Communities 5 and 13

A medium number of species occurs here at medium densities. This ecosite is highly important to the following species: Spotted Sandpiper, Common Flicker, Common Raven, Black-capped Chickadee, Mountain Chickadee, Red-breasted Nuthatch, Swainson's Thrush, Warbling Vireo, Orange-crowned Warbler, Yellow-rumped Warbler, Western Tanager, Chipping Sparrow, Lincoln's Sparrow and Song Sparrow.

HE1

Ecoregion: alpine
Landform: rock residuum
Vegetation: dryas tundra
some heath

Ungulates:
This ecosite is highly important to ungulates - especially sheep and goat in summer but only moderately important in winter. Winter snow accumulation is variable, depending on exposure, but has been recorded as deep as 0.6 m. Forage species on which use was recorded were sedge (*Carex nardina*), fescue (*Festuca saximontana*), alpine bluegrass and willow (*Salix glauca*).

Carnivores:
This ecosite is of high importance to weasels but of low importance to other species.

Small mammals:
Association 1

Few species occur here, but high densities of pika, Columbian ground squirrel and golden-mantled ground squirrel are present on some tracts.

Breeding birds:
Community 18

A low number of species occurs here at low densities. This ecosite is highly important to the following species: Willow Ptarmigan, White-tailed Ptarmigan,

Horned Lark, Water Pipit and Gray-crowned Rosy Finch.

HE2

Ecoregion: alpine
Landform: rock residuum
Vegetation: dryas tundra
much exposed ground

Ungulates:
This ecosite is of low importance to ungulates in winter and moderate importance in summer. It is highly important to bighorn sheep and mountain goats. Winter snow accumulation varies considerably but depths of up to 0.8 m have been recorded. Recorded forage use was similar to HE1.

Carnivores:
This ecosite is not important to carnivores.

Small mammals:
Association 1

This ecosite supports few species and only the golden-mantled ground squirrel occurs in high densities on some tracts.

Breeding birds:
Community 18

A low number of species occurs here at low densities. This ecosite is highly important to the following species: Horned Lark, Water Pipit and Gray-crowned Rosy Finch.

IB1

Ecoregion: lower subalpine
Landform: colluvial landslide deposits
Vegetation: pine-spruce forest

Ungulates:
In autumn and winter this ecosite is highly important to deer, moose and elk. In summer it is of low importance. Forage species on which use was recorded include dwarf birch, prickly rose, willow (*Salix glauca*) and buffaloberry. Maximum recorded snow depth is 0.8 m.

Carnivores:
This ecosite is moderately important to wolf, cougar, wolverine and weasels.

Small mammals:
Association 2

A high number of species occurs here but only the red-backed vole occurs at high density.

Breeding birds:
Community 5

A low number of species occurs here at medium densities. This ecosite is highly important to the following species: Pine Grosbeak.

IB2

Ecoregion: lower subalpine
Landform: colluvial landslide deposits
Vegetation: open coniferous forest
some exposed rock rubble

Ungulates:
Overall this ecosite is of low importance to ungulates. Snow depths up to 1.2 m have been recorded here.

Carnivores:
Like IB1, this ecosite is moderately important to carnivores, principally wolverine.

Small mammals:
Association 1
This ecosite supports a moderate number of species. Pikas and red squirrels occur in high densities on some tracts.

Breeding birds:
Communities 4 and 7
A low number of species occurs here at medium densities. This ecosite is highly important to the following species: Olive-sided Flycatcher, Gray Jay, and Pine Grosbeak.

IB3

Ecoregion: lower subalpine
Landform: colluvial landslide deposits
Vegetation: spruce-fir forest

Ungulates:
Like IB2 this ecosite is of low importance to ungulates. However, some tracts are highly important to moose in winter. A maximum snow depth of 0.7 m was recorded here.

Carnivores:
This ecosite is moderately important to carnivores, notably lynx, marten and weasels.

Small mammals:
Associations 2 and 3
There are few species here and only masked shrew and varying hare occur in high densities.

Breeding birds:
Community 8

A low number of species occurs here at medium densities. This ecosite is highly important to the following species: Common Flicker, Hairy Woodpecker, Mountain Chickadee and Dark-eyed Junco.

JN1

Ecoregion: alpine
Landform: glacial till deposits
Vegetation: heath meadows and dryas tundra

Ungulates:

This ecosite is highly important in summer, especially to bighorn sheep. It is of moderate importance in winter generally but is highly important to sheep and mountain goats. Where they occur the ecosite is also highly important to caribou at all seasons. Snow depth varies in winter due to drifting, and a maximum depth of 1.6 m was recorded. Evidence of browsing was observed on the following species: sedges (*Carex nardina* and *scirpoidea*), fescue (*Festuca saximontana*), wood rush, lousewort (*Pedicularis bracteosa* and *flammea*), alpine bluegrass, willows (*S. arctica, barratiana* and *glauca*) and valerian.

Carnivores:

Like most alpine ecosites this is of low importance to most carnivores. It is of moderate importance to marten and weasels year-round and to wolf and coyote in summer.

Small mammals:

Associations 1 and 5
This ecosite is important to small mammals. A moderate number of species occurs here and there are high densities of pika, hoary marmot, Columbian ground squirrel, and Golden-mantled ground squirrel. The uncommon Richarson's water vole has been recorded on some tracts.

Breeding birds:

Communities 17 and 18
A low number of species occurs here at low densities. This ecosite is highly important to the following species: Common Raven, Water Pipit, Gray-crowned Rosy Finch and Golden-crowned Sparrow.

KA1

Ecoregion: alpine
Landform: alluvial fans
Vegetation: dryas tundra and moist alpine meadow

Ungulates:

This ecosite is highly important to ungulates in summer and moderately in winter, primarily to bighorn sheep. No browse use was recorded on four sample sites and snow depths were not measured.

Carnivores:

This ecosite is not important to carnivores.

Small mammals:

Association 1

A moderate number of species occurs here, none of them in high densities.

Breeding birds:

Communities 10 and 18
A low number of species occurs here at low densities.

LV1

Ecoregion: upper subalpine
Landform: larch-fir forest
Vegetation:

Ungulates:

This ecosite is moderately important to ungulates in winter, but this ranking is based primarily on its high importance to moose. Snow depths were recorded up to one meter and deep snow limits use of this ecosite by other species. Dwarf birch and willow (*S. glauca*) were browsed here.

Carnivores:

This ecosite is of low importance although it may be of high importance to wolves in autumn.

Small mammals:

Associations 5 and 6
A moderate number of species occur here, with high densities of least chipmunk, heather vole, long-tailed vole, and Western jumping mouse. Overall, this is a highly important ecosite.

Breeding birds:

Communities 7 and 8
A low number of species occurs here at low densities.

LV2

Ecoregion: upper subalpine
Landform: glacial till deposits
Vegetation: open spruce-fir forest and heath meadows

Ungulates:

This ecosite is of low importance to ungulates. No browsing evidence was found on three forage use plots. Winter snow depths were recorded as deep as 1 m.

Carnivores:

This ecosite is of low importance overall, but it is highly important to weasels.

Small mammals:

Associations 5 and 6
A moderate number of species occurs here. Hoary marmots, Columbian ground squirrels, heather voles and porcupines occur in high densities. Overall the ecosite is highly important to small mammals.

Breeding birds:

Communities 7 and 17
A low number of species occurs here at low densities. This ecosite is highly important to the following species: Golden-crowned Sparrow.

LV3

Ecoregion: upper subalpine
Landform: glacial till deposits
Vegetation: spruce-fir forest

Ungulates:
This ecosite is highly important to mountain goats and caribou, and is moderately important to ungulates overall. Willows (*Salix barratiana, glauca, candida* and *vestita*) are browsed here. This ecosite typically has deep snow accumulation; maximum recorded depth was 1.5 m.

Carnivores:
This ecosite is moderately important, principally to marten and wolverine.

Small mammals:
Associations 2 and 3
A high number of species occurs here, with high densities of Vagrant shrew, pika, Columbian ground squirrel, Heather vole and porcupines. The uncommon Richarson's water vole occurs on many tracts of this ecosite. This ecosite is highly important to small mammals.

Breeding birds:
Communities 7 and 8
A high number of species occurs here at medium densities. This ecosite is highly important to the following species: Hermit Thrush, Mountain Bluebird, and Townsend's Solitaire. Mountain Bluebird is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

MC1

Ecoregion: lower subalpine
Landform: glaciolacustrine deposits, ridged or gullied
Vegetation: dry areas: moist coniferous forest
wet areas: spruce or birch-willow bogs

Ungulates:
Although this ecosite is of generally low importance, it is of high importance to moose. Shrub species on which use was recorded are dwarf birch and willows (*S. glauca* and *vestita*). Snow depths reach 1.2 m.

Carnivores:
This ecosite is moderately important, notably to marten and lynx.

Small mammals:
Associations 2,3 and 4
Few species occur here, all at low or moderate densities.

Breeding birds:

Communities 5,6,8 and 9
A medium number of species occurs here at low densities.

ML1

Ecoregion: lower subalpine
Landform: glacial till deposits on valley slopes
Vegetation: spruce-fir forest

Ungulates:
This ecosite is of low importance. Maximum recorded snow depth was 0.6 m.

Carnivores:
This ecosite is moderately important, principally to marten, weasels and lynx.

Small mammals:
Associations 2 and 3
A high number of species occur here, with many occuring at high densities: pika, Least chipmunk, Yellow pine chipmunk, Golden-mantled ground squirrel, Gapper's red-backed vole, Heather vole, Western jumping mouse and porcupine. Consequently the ecosite is highly important to small mammals.

Breeding birds:
Community 8
A high number of species occurs here at high densities. This ecosite is highly important to the following species: Olive-sided Flycatcher, Clark's Nutcracker, Townsend's Solitaire, Golden-crowned Kinglet, Yellow-rumped Warbler, Townsend's Warbler and Dark-eyed Junco. Golden-crowned Kinglet is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

ML2

Ecoregion: lower subalpine
Landform: glacial till deposits on valley slopes
Vegetation: pine-spruce forest

Ungulates:
This ecosite is of moderate importance. It is most important to moose in winter. Forage use was recorded on river alder, common juniper, menziesia, lodgepole pine, prickly rose, willows (*S. barclayii, glauca, myrtillifolia,* and *scouleriana*), grouseberry, showy aster, *Spiraea,* and tall bilberry. Maximum recorded snow depth was 0.4 m although snow accumulates to greater depths.

Carnivores:
This ecosite is of low importance. It is of moderate importance to weasels.

Small mammals:
Associations 2 and 3
A moderate number of species occurs here, with high densities of red squirrel, deer mouse, Gapper's red-backed vole, and heather vole.

Breeding birds:
Community 5
A high number of species occurs here at medium densities. This ecosite is highly

important to the following species: Western Wood Peewee, Macgillivray's Warbler and Wilson's Warbler.

ML3

Ecoregion: lower subalpine
Landform: glacial till deposits on valley slopes
Vegetation: spruce–whitebark pine forest

Ungulates:

This ecosite is moderately important in winter at which season it is of high importance to deer and caribou.

Carnivores:

This ecosite is moderately important. It is highly important to marten and is used by wolf and cougar.

Small mammals:

Associations 2 and 3
A moderate number of species occurs here, with high densities of Yellow pine chipmunk , red squirrel, Gapper's red–backed vole and Heather vole.

Breeding birds:

Community 8
A low number of species occurs here at high densities. This ecosite is highly important to the following species: Clark's Nutcracker, Red–breasted Nuthatch, Winter Wren, Varied Thrush, Hermit Thrush, Yellow–rumped Warbler, Pine Siskin and Dark–eyed Junco.

MP1

Ecoregion: alpine
Landform: glacial till deposits
Vegetation: dryas tundra and heath meadows

Ungulates:

This ecosite is of moderate importance. It is highly important to mountain goat and bighorn sheep. Forage plants on which use was recorded are sedges (*Carex nardina* and *scirpoidea*), mountain hairgrass, alpine bluegrass and willows (*S. arctica, barrattiana* and *glauca*). Winter snow depths vary; maximum recorded depth is 1.0 m.

Carnivores:

This ecosite is of low importance, although a high wolverine track density was recorded.

Small mammals:

Associations 1 and 5
A moderate number of species occurs here, with high densities of pika, hoary marmot, Columbian ground squirrel and Golden–mantled ground squirrel.

Breeding birds:

Communities 17 and 18
A low number of species occurs here at low densities. This ecosite is highly

important to the following species: Willow Ptarmigan, White-tailed Ptarmigan, Water Pipit and Gray-crowned Rosy Finch.

MQ1

Ecoregion: alluvial fans
Landform: spruce-fir forest
Vegetation: some patches of shrubbery

Ungulates:
This ecosite is highly important, especially to deer, moose and elk. Forage plants on which use was recorded include dwarf birch, bracted lousewort and willows (*S. glauca* and *vestita*).

Carnivores:
This ecosite is highly important, especially in summer. It receives heavy use by wolf, coyote, marten and wolverine.

Small mammals:
Associations 1,3 and 6
A high number of species occur here. There are high densities of varying hare, Columbian ground squirrel and red squirrel.

Breeding birds:
Communities 7 and 8
A low number of species occurs here at high densities. This ecosite is highly important to the following species: Mountain Chickadee, Hermit Thrush, Golden-crowned Kinglet and Pine Siskin. Golden-crowned Kinglet is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

NG1

Ecoregion: upper subalpine
Landform: glaciofluvial terraces
Vegetation: spruce-fir forest

Ungulates:
This ecosite is of low importance. Shrubs that showed evidence of browsing are swamp birch, shrubby cinquefoil and willows.

Carnivores:
This ecosite is of low importance.

Small mammals:
Associations 3 and 6
A low number of species occurs here and none occur at high densities.

Breeding birds:
Communities 7 and 8
A low number of species occurs here at high densities. This ecosite is highly important to the following species: Pine Siskin, White-crowned Sparrow and Fox Sparrow.

NH1

Ecoregion: montane
Landform: gullied glacio-lacustrine deposits
Vegetation: dry areas: pine-spruce forest
wet areas: spruce bogs

Ungulates:
This ecosite is moderately important, being used most heavily by moose all year round.

Carnivores:
This ecosite is of moderate importance. It is highly important to lynx.

Small mammals:
Associations 2 and 3
A low number of species occur here. The pika and red squirrel occur at high densities.

Breeding birds:
Communities 5 and 6
A high number of species occurs here at medium densities. Occurring only in the lower Athabasca and Snake Indian valleys and having strong boreal affinities, this ecosite may be important to boreal species that wander into Jasper.

NT2

Ecoregion: upper subalpine
Landform: alluvial floodplains and fans
Vegetation: birch-willow meadows
some sedge and grass meadows

Ungulates:
This ecosite is of moderate importance in winter and low importance in summer. All ungulate species have been recorded here. Plants showing evidence of use were wheatgrass, dwarf birch, sedges (*C. aquatilis, nardina, rostrata* and *scirpoidea*), timber oatgrass, tufted hairgrass, bluegrass and willows (*S. barrattiana, bebbiana, glauca, myrtillifolia, planifolia* and *vestita*).

Carnivores:
This ecosite is of moderate importance. It is important to wolf, coyote, marten and cougar.

Small mammals:
Associations 2,4 and 5
This ecosite is highly important, supporting a high number of species including the uncommon water vole and the very rare water shrew, as well as high densities of Meadow vole and Columbian ground squirrel.

Breeding birds:
Community 10
A low number of species occurs here at low densities. This ecosite is highly important to the following species: Spotted Sandpiper, Savannah Sparrow and White-crowned Sparrow.

Reptiles and Amphibians:
This ecosite provides important breeding and foraging habitat for Western toad

NT3

Ecoregion: upper subalpine
Landform: alluvial deposits
Vegetation: sedge and forb meadows
some birch-willow stands

Ungulates:
This ecosite is probably, like NT2, moderately important in winter and of low importance in summer; however, it was not sampled. Maximum recorded snow depth was 1.1 m.

Carnivores:
This ecosite is of low importance.

Small mammals:
Association 4
A low number of species occurs here. The uncommon Richarson's water vole is present, and there are high densities of meadow vole and Western jumping mouse.

Breeding birds:
Communities 14 and 17
A low number of species occurs here at medium densities. This ecosite is highly important to the following species: Spotted Sandpiper, Solitary Sandpiper, Water Pipit and Savannah Sparrow.

Reptiles and Amphibians:
This ecosite provides breeding and foraging habitat for Western toad.

NY1

Ecoregion: montane
Landform: glacial till deposits on steep slopes
Vegetation: Douglas-fir and pine forest

Ungulates:
This ecosite is highly important, especially to deer, elk and bighorn sheep. It provides valuable early spring forage in April and May. Forage species on which use was recorded include pinegrass, hairy wildrye, and prickly rose.

Carnivores:
This ecosite is of high importance, especially to large carnivores such as coyote, wolf and cougar which prey on ungulates.

Small mammals:
Association 1
A moderate number of species occurs on this ecosite. There are high densities of Columbian ground squirrel, red squirrel and deer mouse. The Bushy-tailed wood rat has been recorded here.

Breeding birds:
Communities 3 and 5
A low number of species occurs here at low densities.

NY3

Ecoregion: montane
Landform: gullied ice-contact drift deposits
Vegetation: xeric areas: open Douglas-fir and pine stands, dry low shrubbery and grassland
mesic areas: closed Douglas-fir and pine forest

Ungulates:
This ecosite is highly important, particularly to deer, elk and bighorn sheep. In addition to being valuable winter range due to low snow accumulation and abundant forage and cover, this ecosite provides critical early spring forage. Maximum recorded snow depth is 0.5 m. Forage plants on which use was recorded are bluebunch wheatgrass, milk vetch, northern awnless brome, hairy wildrye, Rocky Mountain fescue, rough fescue, junegrass, bluegrass (*Poa cusickii*), aspen, prickly rose and buffaloberry.

Carnivores:
This ecosite is highly important, especially to cougar, coyote, wolf and marten.

Small mammals:
Associations 1 and 2
A high number of species occurs here and there are high densities of red squirrel, deer mouse, heather vole and long-tailed vole.

Breeding birds:
Communities 3,4,5 and 13
A very high number of species occurs here at high densities. This ecosite is highly important to the following species: Goshawk, Sharp-shinned Hawk, Rufous Hummingbird, Common Flicker, Dusky Flycatcher, American Robin, Townsend's Solitaire, Red-eyed Vireo, Yellow-rumped Warbler, Western Tanager and Dark-eyed Junco. Sharp-shinned Hawk is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

PL1

Ecoregion: upper subalpine
Landform: glacial till deposits on valley slopes
Vegetation: spruce-fir forest

Ungulates:
This ecosite is moderately important. All species except goats make moderate use of the ecosite in summer, but because of heavy snow accumulation few ungulates remain in winter. Maximum recorded snow depth was 1.3 m. Where caribou occur this ecosite is highly important to them. Plants on which use was recorded are dwarf and swamp birch, sedge (*C. scirpoidea*), fireweed, willows (*S. barrattiana, barclayii, bebbiana, glauca, planifolia* and *vestita*), tall bilberry and grouseberry.

Carnivores:

This ecosite is highly important. It receives heavy use by marten and weasels and moderate use by several other species.

Small mammals:

Associations 2,3,6 and 7.
A high number of species occurs here including the uncommon Richarson's water vole. There are high densities of pika, Columbian ground squirrel and Golden-mantled ground squirrel on some tracts.

Breeding birds:

Communities 7 and 8
A high number of species occurs here at low densities. This ecosite is highly important to the following species: Ruby-crowned Kinglet.

PL3

Ecoregion: upper subalpine
Landform: glacial till deposits
Vegetation: larch-fir forest

Ungulates:

This ecosite is of low importance. Based on pellet group counts, it is highly important to deer in winter. No forage use plots were conducted on this ecosite. Maximum recorded snow depth was 1.8 m. and it is probable that few ungulates remain past early winter.

Carnivores:

This ecosite is of low importance. High densities of wolverine tracks were recorded.

Small mammals:

Associations 5 and 6
Few species occur here. There are high densities of least chipmunk, heather vole and meadow vole.

Breeding birds:

Communities 7 and 8
A medium number of species occurs here at low densities. This ecosite is highly important to the following species: Mountain Bluebird.

PL4

Ecoregion: upper subalpine
Landform: glacial till deposits
Vegetation: open spruce-fir forest and heath meadows

Ungulates:

In summer this ecosite is highly important and in autumn it is moderately important. Snow depths have been recorded to 1.8 m, which would restrict ungulates in winter. Mountain goat and bighorn sheep are the species occurring in highest densities. Forage species include sedges (*Carex scirpoidea* and *vaginata*) bracted lousewort, alpine bluegrass and willows (*Salix arctica, barrattiana, glauca and vestita*).

Carnivores:

This ecosite is moderately important, being highly important to weasels and wolverine.

Small mammals:

Associations 5 and 6
A moderate number of species occurs here and there are high densities of the least chipmunk, hoary marmot, Columbian ground squirrel and red-backed vole.

Breeding birds:

Communities 7 and 17
A medium number of species occurs here at medium densities. This ecosite is highly important to the following species: Townsend's Solitaire and Water Pipit.

PL5

Ecoregion: upper subalpine
Landform: ridged glacial till deposits
Vegetation: dry areas: spruce-fir or larch-fir forest
wet areas: willow shrubbery

Ungulates:

This ecosite is moderately important in summer and of low importance in winter. Snow has been recorded to 1.4 m deep, which would eliminate ungulates in winter. Browsing was recorded on dwarf birch, swamp birch, willows (*S. barratiana, farrae, glauca* and *vestita*) and tall bilberry.

Carnivores:

This ecosite is moderately important, especially to marten, weasels and wolverine. It is highly important to wolf and coyote in summer.

Small mammals:

Associations 1,3,5 and 6
This ecosite supports a moderate number of species. The pika, Columbian ground squirrel and heather vole are found in high densities.

Breeding birds:

Communities 7,8 and 10
A high number of species occurs here at low densities. This ecosite is highly important to the following species: Willow Ptarmigan, Ruby-crowned Kinglet and Gray-crowned Rosy Finch.

PP1

Ecoregion: lower subalpine
Landform: alluvial fans
Vegetation: pine forest

Ungulates:

PP1 is moderately important, particularly to elk, deer and moose. Snow was recorded to 0.9m deep, which would restrict ungulate presence in winter. Forage use was recorded on dwarf birch, aspen and prickly rose.

Carnivores:
This ecosite is highly important, principally to wolf, coyote, cougar and lynx.

Small mammals:
Associations 1 and 2
A high number of species occurs here. The varying hare, Columbian ground squirrel, golden-mantled ground squirrel, red squirrel and red-backed vole are found in high densities. The flying squirrel has been recorded here.

Breeding birds:
Community 5
A medium number of species occurs here at medium densities. This ecosite is highly important to the following species: Swainson's Thrush and Yellow-rumped Warbler.

Reptiles and Amphibians:
This ecosite provides important Western toad breeding and foraging habitat.

PP2

Ecoregion: lower subalpine
Landform: alluvial fans
Vegetation: poplar forest

Ungulates:
This ecosite was not surveyed for pellet group counts. It is moderately important to ungulates, being highly important to elk year-round and to deer in winter. Snow depths of 0.6m have been recorded here.

Carnivores:
This ecosite is very highly important, especially to coyote, wolf, weasels and cougar.

Small mammals:
Association 1
A moderate number of species occurs here. Dusky shrews, red squirrels, deer mice and meadow voles occur in high densities.

Breeding birds:
Community 1
A medium number of species occurs here at medium densities. Species of birds on this ecosite should be similar to those on HD1.

PP3

Ecoregion: lower subalpine
Landform: alluvial fans
Vegetation: spruce-fir or white spruce forest

Ungulates:
This ecosite is moderately important, especially to moose, elk and deer. Like PP1, snow depth was recorded to 0.9 m. Forage use was recorded on dwarf birch, prickly rose, willows (*Salix barclayii* and *planifolia*) and buffaloberry.

Carnivores:

This ecosite is highly important, especially to lynx. It is moderately important to wolf, coyote, marten, weasels, wolverine and cougar.

Small mammals:

Associations 1 and 2
A high number of species and high densities of varying hares, golden-mantled ground squirrels, deer mice and porcupines occur here.

Breeding birds:

Community 8
A high number of species occurs here at medium densities. This ecosite is highly important to the following species: Ruffed Grouse, Boreal Chickadee and Golden-crowned Kinglet. Golden-crowned Kinglet is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

Reptiles and Amphibians:

This ecosite provides important Western toad breeding and foraging habitat.

PP4

Ecoregion: lower subalpine
Landform: glaciofluvial fans and terraces
Vegetation: dryas mats with scattered spruce some exposed gravel

Ungulates:

This ecosite is moderately important, especially to moose and elk. Snow depths up to 0.6m were recorded. Forage use was recorded on dwarf birch, sedge (*Carex rostrata* and *scirpoides*), hairy wildrye, prickly rose, willows (*Salix farrae* and *glauca*) and buffaloberry.

Carnivores:

This ecosite is moderately important, notably to wolf, coyote, weasel and wolverine.

Small mammals:

Association 1
A moderate number of species is found here, all occurring at moderate or low densities.

Breeding birds:

Community 15
A medium number of species occurs here at low densities. This ecosite is highly important to the following species: Killdeer.

Reptiles and Amphibians:

This ecosite provides important Western toad breeding and foraging habitat.

PP6

Ecoregion: lower subalpine
Landform: alluvial fans
Vegetation: open spruce-fir forest
shrub meadows

Ungulates:

This ecosite is highly imporatnt. All species have been recorded here and it is highly important to elk and moose. Snow depth varies, and has been recorded as deep as 1.2 m, which is too deep for most ungulates. Forage use was recorded on dwarf birch, swamp birch, hairy wildrye, and willows (*Salix barclayii, bebbiana, farrae* and *glauca*).

Carnivores:

This ecosite is very highly important, being highly important to wolf, coyote, weasel and lynx and moderately important to marten, wolverine and cougar.

Small mammals:

Association 1
There is a moderate number of species on this ecosite. The varying hare, least chipmunk and deer mouse occur in high densities.

Breeding birds:

Community 7
A high number of species occurs here at low densities.

Reptiles and Amphibians:

This ecosite provides important Western toad breeding and foraging habitat.

PP7

Ecoregion: lower subalpine
Landform: alluvial fans
Vegetation: birch meadows
some grasslands

Ungulates:

This ecosite is very highly important to ungulates, especially elk and moose. Forage use was recorded on willows, dwarf and swamp birch, and shrubby cinquefoil. Snow depths of up to 0.7 m were recorded, which would restrict winter use by ungulates.

Carnivores:

This ecosite is highly important to carnivores, principally to wolf and coyote. It is moderately important to cougar and lynx.

Small mammals:

Associations 1 and 7
This ecosite supports a moderate number of species. Only the Columbian ground squirrel is found in high densities.

Breeding birds:

Community 10
A medium number of species occurs here at low densities. This ecosite is highly important to the following species: Savannah Sparrow, Clay-coloured Sparrow and White-crowned Sparrow.

Reptiles and Amphibians:
This ecosite provides important Western toad breeding and foraging habitat.

PR1

Ecoregion: lower subalpine
Landform: glacial till deposits on valley slopes
Vegetation: pine forests

Ungulates:
PR1 is of low importance to ungulates, although it is highly important to deer in winter. Snow depths up to 1.1 m were recorded here.

Carnivores:
This ecosite is highly important, since all carnivore species occur here and high densities of wolverine tracks were recorded.

Small mammals:
Associations 2 and 3
The flying squirrel and bushy-tailed wood rat occur on this ecosite and the diversity of other species is high. The Columbian and golden-mantled ground squirrels occur in high densities.

Breeding birds:
Community 5
A medium number of species occurs here at high densities. This ecosite is highly important to the following species: Winter Wren, Pine Siskin and White-winged Crossbill.

PR2

Ecoregion: lower subalpine
Landform: glacial till deposits on valley slopes
Vegetation: pine-spruce forest

Ungulates:
This ecosite is moderately important to ungulates year-round although snow was recorded to 1.0 m deep. All ungulate species have been reported on this ecosite, with elk and bighorn sheep the most frequent. Many species of plants showed signs of foraging but only willows (*Salix glauca*), grouseberry and pine grass were consistently eaten.

Carnivores:
This ecosite is very highly important to carnivores. It is highly important to marten, weasel and lynx. It is less important to larger species in winter because of deep snow and few ungulates.

Small mammals:
Associations 1 and 2
A high number of species occurs here, including the very rare pygmy shrew. The varying hare, Columbian ground squirrel, golden-mantled ground squirrel, red squirrel and red-backed vole occur in high densities.

Breeding birds:

Community 5
A very high number of species occurs here at high densities. This ecosite is highly important to the following species: Townsend's Solitaire, Western Tanager, Red Crossbill and Yellow-rumped Warbler.

PR3

Ecoregion: lower subalpine
Landform: glacial till deposits
Vegetation: pine forest
some spruce-fir forest

Ungulates:
This ecosite is of low importance to ungulates but some tracts are highly important to moose in winter. Snow depths to 0.6 m have been recorded here. Little sign of foraging was found on this ecosite.

Carnivores:
This ecosite is moderately important to carnivores, particularly marten and lynx.

Small mammals:
Association 2
This ecosite supports a high number of species and high densities of red-backed and long-tailed voles.

Breeding birds:
Community 5
A medium number of species occurs here at medium densities.

PR4

Ecoregion: lower subalpine
Landform: gullied ice-contact drift deposits
Vegetation: northerly aspects: spruce-fir forest, some pine
southerly aspects: pine forest

Ungulates:
This ecosite is moderately important to ungulates in winter but of low importance in summer. Snow depths reach at least 1.0 m. Forage use was recorded on swamp birch, pinegrass, hairy wild-rye, prickly rose, willows (*Salix farrae, glauca* and *vestita*) and buffaloberry.

Carnivores:
This ecosite is highly important, especially to coyote, marten and wolverine.

Small mammals:
Associations 1,2 and 3
The diversity of small mammals as well as the occurrence of the flying squirrel and bushy-tailed wood rat on this ecosite make it important for small mammals. There are high densities of golden-mantled ground squirrels, red squirrels, deer mice, red-backed voles, long-tailed voles and western jumping mice.

Breeding birds:

Communities 5 and 8
A medium number of species occurs here at medium densities.

PR6

Ecoregion: lower subalpine
Landform: ice-contact drift deposits
Vegetation: pine forest

Ungulates:
This ecosite is of low importance, although it is highly important to deer in summer. Snow depths were recorded to 0.8 m. Willows were browsed on this ecosite.

Carnivores:
This ecosite is highly important, especially to marten and lynx and, in summer, wolf, coyote and cougar.

Small mammals:
Associations 2 and 3
A moderate number of species is found here. There are high densities of varying hares and porcupines. Flying squirrels have been recorded here.

Breeding birds:
Community 5
A high number of species occurs here at low densities. This ecosite is highly important to the following species: Ruby-crowned Kinglet and Yellow-rumped Warbler.

PT1

Ecoregion: montane
Landform: glacial till deposits
Vegetation: pine forest
scattered aspens

Ungulates:
This ecosite is moderately important in summer and highly important in winter. Low snow accumulation and abundant forage make this ecosite important to deer and elk year-round. Forage use was recorded on bluebunch wheat grass, shrubby cinquefoil, aspen, prickly rose, willows, buffaloberry, mountain ash and white meadowsweet.

Carnivores:
This ecosite is very highly important, notably to coyote and cougar in summer. It is highly important to coyote and cougar in winter and to wolf year-round. All other species of carnivores have been recorded here.

Small mammals:
Associations 1 and 2
A high number of species occurs here. Bushy-tailed wood rats and bats have been recorded here. Red squirrels and red-backed voles occur in high densities.

Breeding birds:

Community 5
A high number of species occurs here at high densities. This ecosite is highly important to the following species: Sharp-shinned Hawk, Common Raven, Solitary Vireo and Yellow-rumped Warbler. Sharp-shinned Hawk is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

Reptiles and Amphibians:
The uncommon Wandering garter snake has been recorded on this ecosite near Vermilion Lakes and Cave and Basin in Banff. Ponds are important breeding sites for Long-toed salamander and Wood frog.

PT3

Ecoregion: montane
Landform: glacial till deposits
Vegetation: pine forest
some Douglas-fir stands

Ungulates:
This ecosite is highly important to ungulates in winter primarily because of low snow depths and abundant forage. In summer it is of low importance. Species most frequently found here are deer, moose and elk. Forage use was recorded on saskatoon-berry, timber milk-vetch, aspen, prickly rose and willow (*Salix glauca*.

Carnivores:
This ecosite is highly important, principally to wolf, coyote and cougar. It is moderately important to marten and lynx.

Small mammals:
Associations 1 and 2
A moderate number of species occurs here. Big brown bats forage here and red squirrels and deer mice occur in high densities.

Breeding birds:
Community 5
A high number of species occurs here at high densities. This ecosite is highly important to the following species: Rough-winged Swallow, American Robin, Solitary Vireo and Pine Siskin.

Reptiles and Amphibians:
The uncommon Wandering garter snake was recorded on this ecosite at three locations in Jasper.

PT4

Ecoregion: montane
Landform: glacial till deposits
Vegetation: aspen forest
some lodgepole pine

Ungulates:
PT4 is moderately important year-round, being very highly important to deer and highly important to elk and bighorn sheep. Snow depths never exceeded 0.5 m on our transects here. Forage species on which use was recorded were

saskatoon-berry, showy aster, northern awnlss brome, aspen and prickly rose

Carnivores:

This ecosite is highly important to wolf, coyote and cougar. Marten is the only other carnivore that was recorded here.

Small mammals:

Association 1

Few species occurs here. Red squirrels and meadow voles occur in high densities

Breeding birds:

Community 1

A high number of species occurs here at very high densities. This ecosite is highly important to the following species: Least Flycatcher, Barn Swallow, Black-capped Chickadee, Mountain Chickadee, Boreal Chickadee, American Robin, Swainson's Thrush, Cedar Waxwing, Solitary Vireo, Warbling Vireo, Yellow-rumped Warbler, Brown-headed Cowbird and Pine Siskin.

PT5

Ecoregion: montane
Landform: ridged glacial till deposits
Vegetation: dry areas pine forest, some Douglas-fir
wet areas spruce or willow bog

Ungulates:

This ecosite is highly important in winter and moderately important in summer, especially to deer. Snow depths reached 0.6 m on the PT5 tracts sampled. Forage use was recorded on mountain alder, showy aster, timber milk vetch, sedges (*Carex aquatilis, rostrata* and *vaginata*), pine grass, hairy wildrye, pea vine, bracted honeysuckle, menziesia, aspen, prickly rose and willows (*Salix farrae, glauca, planifolia* and *scouleriana*).

Carnivores:

Like other PT ecosites, PT5 is highly important to carnivores, particularly coyote, cougar and lynx.

Small mammals:

Associations 2,3 and 4

This ecosite supports a moderate number of species. Flying squirrels are present and varying hares, red squirrels and medaow voles are found in high densities

Breeding birds:

Communities 5 and 6

A high number of species occurs here at high densities. This ecosite is highly important to the following species: Sharp-shinned Hawk, Olive-sided Flycatcher, Swainson's Thrush, Solitary Vireo, Yellow-rumped Warbler and Western Tanager. Sharp-shinned Hawk is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

RD1

Ecoregion: alpine
Landform: colluvial slopes
Vegetation: dryas tundra and heath meadow

Ungulates:

This ecosite is very highly important in summer and moderately important in winter. These tracts are very highly important to bighorn sheep and highly important to mountain goats partially because they tend to be blown free of snow in winter. Forage species include sedge (*Carex nardina*), Rocky Mountain fescue, junegrass, alpine bluegrass, and arctic willow.

Carnivores:

The importance of this ecosite is low, although it is moderately important to wolf, coyote and cougar in summer.

Small mammals:

Associations 1 and 5
A moderate number of species uses this ecosite. High densities of pikas, hoary marmots, Columbian ground squirrels and golden-mantled ground squirrels occur here.

Breeding birds:

Communities 17 and 18
A low number of species occurs here at low densities. This ecosite is highly important to the following species: Horned Lark and Gray-crowned Rosy Finch.

RK1

Ecoregion: montane
Landform: glaciolacustrine deposits
Vegetation: moist pine forest

Ungulates:

This ecosite is moderately important, being very highly important to elk.

Carnivores:

This ecosite is moderately important, particularly to wolf, coyote, cougar and lynx.

Small mammals:

Association 2
The diversity and density of small mammals on this ecosite are high. Masked shrews, varying hares, least chipmunks, red squirrels and deer mice occur at high densities.

Breeding birds:

Communities 5 and 6
A high number of species occurs here at medium densities. Species of birds that occur here should be similar to those on PT5.

RO

Ecoregion: variable
Landform: bedrock
Vegetation: none

Ungulates:

Although rock is widespread and when sheer or bare of vegetation is rarely used by ungulates, some tracts can be very highly important to mountain goats, bighorn sheep and caribou. Such areas are used as escape terrain and minor foraging area adjacent to more important ecositess such as those of the SB, TR, WF and other ecosections.

Carnivores:

Because of difficulty of access, RO areas are of no importance to carnivores. Where RO is used as escape terrain by ungulates, it is of negative value to carnivores.

Birds:

Rock faces are used by raptors, particularly golden eagles, for nesting.

SB1

Ecoregion: lower subalpine
Landform: colluvial slopes with active avalanching
Vegetation: avalanche shrubbery and meadows
some spruce-fir forest

Ungulates:

SB1 is highly important year-round, especially to mountain goat and bighorn sheep. Avalanche activity maintains shrub habitat dominated by aspen, willow, dwarf and swamp birch, and shrubby cinquefoil. Forage use was recorded on mountain alder, American milk vetch, hedysarum, menziesia and swamp currant. Avalanche activity may restrict mid-winter use of this ecosite and snow depths up to 1.2 m have been recorded. The spruce forests provide cover for ungulates.

Carnivores:

This ecosite is moderately important, notably to coyote, cougar and weasels.

Small mammals:

Associations 2 and 3
The diversity and density of small mammals on this ecosite are high. Masked shrew, pika, least chipmunk, deer mouse, long-tailed vole and western jumping mouse occur at high densities.

Breeding birds:

Communities 8,10,11,12 and 16
A high number of species occurs here at medium densities. This ecosite is highly important to the following species: Rufous Hummingbird, Dusky Flycatcher, Macgillivray's Warbler, Wilson's Warbler and Pine Siskin.

Reptiles and Amphibians:

This ecosite is important to Western toad.

SB2

Ecoregion: lower subalpine
Landform: colluvial slopes

Vegetation: spruce-fir forest

Ungulates:

This ecosite is moderately important to ungulates. The coniferous forest offers limited opportunities for foraging but provides valuable cover where the tracts are adjacent to unforested slopes. Moose and elk are the most abundant ungulates here. The maximum recorded snow depth is 0.8 m which would restrict ungulate movement. Forage species used on plots on this ecosite were mountain alder, saskatoon-berry, showy aster, dwarf birch, swamp birch, northern awnless brome, Indian paintbrush, hairy wildrye, fireweed, alpine bluegrass, aspen, prickly rose, and willows (*Salix scouleriana* and *vestita*).

Carnivores:

This ecosite is of low importance to carnivores.

Small mammals:

Associations 2 and 3

A low number of species is found on this ecosite. Only the western jumping mouse occurs in high densities.

Breeding birds:

Community 8

A medium number of species occurs here at medium densities. This ecosite is highly important to the following species: Yellow-rumped Warbler and Wilson's Warbler.

SB3

Ecoregion: lower subalpine
Landform: colluvial slopes
Vegetation: pine forest

Ungulates:

This ecosite is moderately important in winter and of low importance in summer. In autumn and winter it is most important to moose and bighorn sheep. Snow depths of up to 0.8 m were recorded. Forage use was recorded on showy aster, swamp birch, hairy wildrye, june grass, bracted honeysuckle, aspen, prickly rose, wild red raspberry, and willows (*S. farrae, glauca* and *scouleriana*).

Carnivores:

This ecosite is highly important, particularly to marten, wolverine and coyote in autumn and winter. It is moderately important to wolf, cougar and lynx.

Small mammals:

Associations 1,2 and 7

There is a moderate number of species and high densities of varying hares and yellow pine chipmunks on this ecosite.

Breeding birds:

Community 5

A low number of species occurs here at low densities.

SB4

Ecoregion: lower subalpine
Landform: colluvial slopes
Vegetation: open coniferous forest
some forb meadows and exposed rock

Ungulates:

In autumn and winter this ecosite is highly important to ungulates but in summer it is of low importance. Forage species upon which use was recorded are hairy wildrye, june grass, aspen, prickly rose, willows (*Salix bebbiana, glauca, lasiandra* and *vestita*) and buffaloberry.

Carnivores:

The importance of this ecosite to carnivores is low.

Small mammals:

Association 1
A high number of species occurs on this ecosite. High densities of pikas and least chipmunks occur here. The Bushy-tailed wood rat is present.

Breeding birds:

Communities 4,5, and 7
A medium number of species occurs here at medium densities. This ecosite is highly important to the following species: American Kestrel, Willow Flycatcher, Dusky Flycatcher, Townsend's Solitaire, Ruby-crowned Kinglet and Yellow-rumped Warbler. Willow Flycatcher is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

SB5

Ecoregion: lower subalpine
Landform: colluvial slopes
Vegetation: avalanche grassland

Ungulates:

This ecosite is very highly important to ungulates. Deer, elk, mountain goat and bighorn sheep all make extensive use of these tracts. The ecosite tends to be open and wind blown, which greatly reduces snow accumulation. Forage use was recorded on bluebunch wheat grass, timber milk vetch, fringed brome, northern awnless brome, indian paintbrush, tufted hair grass, hairy wildrye, rocky mountain fescue, northern bedstraw, junegrass, aspen, prickly rose, and buffaloberry.

Carnivores:

This ecosite is moderately important, especially to wolf, coyote and cougar.

Small mammals:

Association 1
This ecosite supports a high number of species. The bushy-tailed wood rat has been recorded here. Only the ubiquitous deer mouse is found in high densities.

Breeding birds:

Communities 1 and 6
A low number of species occurs here at low densities. This ecosite is highly important to the following species: Blue Grouse and Townsend's Solitaire.

SC

Ecoregion: variable
Landform: coarse alluvium
Vegetation: none; occasional patches of sedge, dryas and willows

Ungulates:

Unvegetated stream channels are of low importance to ungulates. However most stream channels include some shrubs which makes them moderately important to moose.

Carnivores:

Frozen stream channels are used as winter travel routes for wolverine, coyotes and wolves. There is low use by marten and mink and moderate use by weasels.

Birds:

Spotted Sandpiper, Killdeer, American Dipper and Harlequin Duck use this habitat.

SF1

Ecoregion: upper subalpine
Landform: glacial till deposits on valley slopes; permafrost
Vegetation: spruce-fir forest

Ungulates:

This ecosite is highly important in summer and moderately important in winter. Snow depths were recorded to 0.8 m, a depth which restricts animal movement. In summer the ecosite is most important to elk. Forage use was recorded on hairy wildrye and willows (*Salix bebbiana* and *vestita*).

Carnivores:

This ecosite is moderately important to carnivores, principally wolf, coyote and cougar when the tracts are relatively snow free.

Small mammals:

Associations 2 and 3
A low number of species occur on this ecosite. The varying hare, red-backed vole and porcupine occur in high densities.

Breeding birds:

Community 8
A low number of species occurs here at medium densities. This ecosite is highly important to the following species: Olive-sided Flycatcher, Gray Jay, Mountain Chickadee, Hermit Thrush and Wilson's Warbler.

SP1

Ecoregion: lower subalpine
Landform: glacio-lacustrine deposits
Vegetation: pine forest
some spruce-fir forest

Ungulates:

This ecosite is highly important in summer and moderately important in winter. It

is highly important to elk year-round. Snow depths were recorded to 1.2 m, a depth that restricts ungulate movement. Forage use was recorded on sedges (*Carex rostrata* and *scirpoides*), venus-slipper, hairy wildrye, prickly rose, willows (*Salix bebbiana* and *glauca*) and buffaloberry.

Carnivores:

This ecosite is moderately important, especially to wolf, coyote and cougar.

Small mammals:

Associations 2 and 3

A low number of species occurs on this ecosite. The flying squirrel has been recorded here. Only the red squirrel occurs in high densities.

Breeding birds:

Community 5

A low number of species occurs here at medium densities. This ecosite is highly important to the following species: Swainson's Thrush, Yellow-rumped Warbler and Pine Siskin.

SX1

Ecoregion: upper subalpine
Landform: glacial till deposits; some tracts with glacio-lacustrine deposits
Vegetation: herb meadows

Ungulates:

This ecosite is moderately important in summer and of low importance in winter. It is highly important in autumn and winter to caribou where they occur. Very deep snow (recorded up to 1.6 m) inhibits ungulate movement. Forage use was recorded on sedges (*Carex aquatilis* and *scirpoidea*), tufted hair grass, timothy grass, bluegrass (*Poa alpina* and *epilis*) and willows (*Salix arctica* and *barratiana*).

Carnivores:

This ecosite is moderately important, particularly to wolf, coyote and cougar in summer and weasel and marten year-round.

Small mammals:

Association 4

This ecosite is highly important for small mammals. The density of small mammals is high, there is a moderate number of species, and the ecosite sustains high densities of the dusky shrew, hoary marmot, Columbian ground squirrel, northern bog lemming, long-tailed vole and porcupine. The uncommon Richarson's water vole occurs on this ecosite.

Breeding birds:

Communities 10 and 17

A high number of species occurs here at low densities. This ecosite is highly important to the following species: Willow Ptarmigan and Water Pipit.

SX2

Ecoregion: upper subalpine
Landform: glacial till deposits; some tracts with glacio-lacustrine deposits

Vegetation: open spruce-fir forest
some willow and forb meadows

Ungulates:

The importance of this ecosite is very similar to SX1 except that this ecosite is highly important to moose in summer. Deep snow (recorded up to 1.3 m) limits ungulate activity in winter. Forage species on which use was recorded include bluebunch wheat grass, dwarf birch, sedges (*Carex scirpoidea*), hairy wildrye, bracted lousewort, timothy, alpine bluegrass, shrubby cinquefoil, willows (*Salix arctica, barrattiana, glauca* and *vestita*) and globe-flower.

Carnivores:

This ecosite is highly important, notably to marten, weasel and wolverine, species which can negotiate deep snow.

Small mammals:

Association 4
A high number of species, including the uncommon water vole, occurs here. There are high densities of the masked shrew, Columbian ground squirrel, red-backed vole, heather vole and porcupine.

Breeding birds:

Communities 7,10 and 17
A high number of species occurs here at medium densities. This ecosite is highly important to the following species: Varied Thrush, Gray-cheeked Thrush, Pine Siskin and Golden-crowned Sparrow.

SX3

Ecoregion: upper subalpine
Landform: glacial till deposits
Vegetation: larch--fir forest

Ungulates:

This ecosite is more important to ungulates than either SX1 or SX2; in winter it is moderately important while in summer it is highly important. It is most important to bighorn sheep and caribou, where they occur. Snow depths were recorded up to 1.2 m, a depth that restricts ungulate movements. Forage use was recorded on swamp birch, hairy wildrye, fireweed, Rocky Mountain fescue, golden sedge, bluegrass (*Poa alpina* and *epilis*), willows(*Salix arctica, barrattiana,* and *glauca*).

Carnivores:

This ecosite is moderately important, principally to wolf, coyote and cougar when snow is not deep.

Small mammals:

Associations 2 and 4
The occurrence of the water vole and beaver in this upper subalpine ecosite make it important for small mammals. A moderate number of species is found on this ecosite.

Breeding birds:

Community 10
A medium number of species occurs here at high densities. This ecosite is highly

important to the following species: Spotted Sandpiper, Varied Thrush, Savannah Sparrow Brewer's Sparrow and White-crowned Sparrow.

TA2

Ecoregion: montane
Landform: silt deposits on valley slopes
Vegetation: dry grassland
scattered spruce clumps

Ungulates:

This ecosite is very highly important to ungulates, particularly deer and elk. Where it is adjacent to escape terrain in the Athabasca valley it is highly important to bighorn sheep. Snow accumulation is low (maximum recorded was 0.3 m), facilitating winter foraging by ungulates. Forage use was recorded on wheatgrasses, northern awnless brome, Rocky Mountain fescue, creeping juniper and junegrass.

Carnivores:

This ecosite is moderately important, being highly important to wolf, coyote and cougar.

Small mammals:

Association 1
A low number of species occurs here. Deer mice and heather voles are found in high densities.

Breeding birds:

Communities 4 and 13
A low number of species occurs here at medium densities. This ecosite is highly important to the following species: Common Flicker, Yellow-rumped Warbler, Vesper Sparrow, Dark-eyed Junco and Chipping Sparrow.

TA3

Ecoregion: montane
Landform: silt deposits on valley slopes
Vegetation: spruce forest

Ungulates:

This ecosite is highly important, especially to deer, moose, elk and - when adjacent to escape terrain - bighorn sheep. Snow accumulation (maximum recorded was 0.4 m) is slightly more than TA2 because the forest cover collects drifting snow and protects it against thaw by shading it. The forest provides cover for ungulates that forage in nearby grass and shrublands.

Carnivores:

This ecosite is highly important, particularly to wolf, coyote, cougar and marten.

Small mammals:

Associations 1 and 2
There are few species on this ecosite. Only the red squirrel occurs in high densities.

Breeding birds:

Community 5
A high number of species occurs here at high densities. This ecosite is highly important to the following species: Mountain Chickadee, Red-breasted Nuthatch, Swainson's Thrush and Yellow-rumped Warbler.

TK1

Ecoregion: alpine
Landform: colluvial slopes
Vegetation: heath meadow and dryas tundra

Ungulates:

This ecosite is of low importance to ungulates. No sign of foraging was recorded on forage use plots.

Carnivores:

The importance of this ecosite is low.

Small mammals:

Associations 1 and 5
Few species occur on this ecosite and only the pika appears in high densities.

Breeding birds:

Communities 17 and 18
A low number of species occurs here at medium densities. Species of birds that occur here should be similar to those on RD1.

TR1

Ecoregion: upper subalpine
Landform: glacial till deposits
Vegetation: shrub meadows
some spruce and fir stands and forb meadows

Ungulates:

This ecosite is highly important to ungulates, especially elk and bighorn sheep. Deep snow (recorded up to 1.2 m) limits winter use but during most of the year there is an abundance of forage on this ecosite. Forage species on which use was recorded include bluebunch wheat grass, dwarf birch, sedges, hairy wildrye, Rocky Mountain fescue, rough fescue, bluegrass (*Poa alpina* and *cusickii*) and willows (*Salix artica, barrattiana, bebbiana, candida, ferrae, glanca,* and *vestita*).

Carnivores:

This ecosite is highly importance to carnivores, notably coyote, wolf and cougar.

Small mammals:

Associations 1 and 7
A high number of species is found on this ecosite as well as high densities of the least chipmunk and hoary marmot. The rare water shrew has been found on this ecosite. The presence of this shrew and the high diversity of species make this ecosite important for small mammals.

Breeding birds:

Communities 10 and 17
A high number of species occurs here at medium densities. This ecosite is highly important to the following species: White-tailed Ptarmigan, American Robin, Horned Lark, Water Pipit, White-crowned Sparrow and Golden-crowned Sparrow.

TR2

Ecoregion: upper subalpine
Landform: glacial till deposits
Vegetation: forb meadows
some clumps of spruce and fir

Ungulates.

Like TR1, this ecosite is highly important to ungulates. Comments about TR1 apply here.

Carnivores:

This ecosite is highly important to carnivores, principally coyote, weasel, wolf and cougar.

Small mammals:

Association 1
A moderate number of species occur on this ecosite. All are found at moderate or low densities.

Breeding birds:

Communities 12,16 and 18
A low number of species occurs here at medium densities. This ecosite is highly important to the following species: American Robin, Brewer's Sparrow and White-crowned Sparrow.

TZ1

Ecoregion: lower subalpine
Landform: ice-contact drift deposits
Vegetation: pine forest with reindeer lichen understory

Ungulates:

This ecosite is of low importance to ungulates, but tracts in northern Jasper are highly important to caribou in winter. No forage use plots were conducted on this ecosite.

Carnivores:

This ecosite is moderately important to carnivores, particularly weasel and lynx. It is of low importance to wolf, coyote, marten, wolverine and cougar.

Small mammals:

Association 2
This ecosite supports few species but high densities of red squirrels, red-backed voles and heather voles.

Breeding birds:

Communities 3 and 7
A low number of species occurs here at medium densities. This ecosite is highly important to the following species: Gray Jay, Ruby-crowned Kinglet and Yellow-rumped Warbler.

TZ2

Ecoregion: lower subalpine
Landform: glaciofluvial deposits
Vegetation: ???

Ungulates:
Like TZ1, this ecosite is of low importance to ungulates except in northern Jasper where tracts are highly important in winter to caribou. No forage use was recorded. Shallow snow depths (up to 0.4 m) were recorded on winter track count transects.

Carnivores:
This ecosite is moderately important to carnivores, particularly weasel and lynx. It is of low importance to wolf, coyote, marten, wolverine and cougar.

Small mammals:
Associations 2,3 and 4
Few species are found on this ecosite. The water vole has been recorded here and the varying hare and porcupine occur in high densities.

Breeding birds:
Communities 3 and 7
A low number of species occurs here at low densities. This ecosite is highly important to the following species: Varied Thrush, Ruby-crowned Kinglet and Yellow-rumped Warbler.

VD1

Ecoregion: lower subalpine
Landform: alluvial fans
Vegetation: spruce-fir forest

Ungulates:
This ecosite is of low importance to ungulates. Snow depths of 1.3 m were recorded, sufficient to restrict ungulate activity. Little sign of foraging was recorded on forage use plots.

Carnivores:
This ecosite is highly importance to carnivores expecially to weasel and lynx. It is moderately important to wolf, coyote, marten and wolverine.

Small mammals:
Associations 2 and 3
There is a moderate number of species on this ecosite. Varying hares, red squirrels and red-backed voles occur in high densities.

Breeding birds:
Community 8

A low number of species occurs here at low densities. This ecosite is highly important to the following species: Golden-crowned Kinglet and Blackpoll Warbler. Golden-crowned Kinglet is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

VD2

Ecoregion: lower subalpine
Landform: alluvial fans
Vegetation: spruce-fir forest

Ungulates:

Like VD1, this ecosite is of low importance to ungulates although some tracts are highly important to moose. The maximum recorded snow depth was 0.6 m. Browse species on which use was recorded include swamp birch, shrubby cinquefoil, prickly rose, willows (*Salix glauca* and *myrtillifolia*), buffaloberry, tall bilberry and grouseberry.

Carnivores:

This ecosite is highly important to carnivores, especially to weasel, marten, and wolverine. It is moderately important to wolf, cougar and lynx.

Small mammals:

Association 2
This ecosite supports a high number of species but none of these occurs at a high density.

Breeding birds:

Community 5
A medium number of species occurs here at low densities. This ecosite is highly important to the following species: White-winged Crossbill.

VL1

Ecoregion: montane
Landform: alluvial floodplain deposits
Vegetation: sedge and wet shrub meadows
some spruce bogs

Ungulates:

This ecosite is highly important in winter, especially to elk and moose. In summer its importance is low. Snow depths were not recorded greater than 0.5 m and chinooks keep the snow shallow much of the winter. Forage use was recorded on mountain alder, dwarf birch, sedges (*Carex aquatilis* and *rostrata*), prickly rose and willows.

Carnivores:

This ecosite is moderately important, being highly important to weasels and, in winter, to wolf and coyote.

Small mammals:

Association 4
The density of small mammals as well as the occurrence of bats, muskrats and beavers in this montane ecosite make it highly important for small mammals. A moderate number of species are found here and beavers and meadow voles

occur in high densities. Wetland ecosites such as this one are very highly important to muskrat survival in the mountains.

Breeding birds:

Communities 9 and 14

A very high number of species occurs here at very high densities. This ecosite is highly important to the following species: American Bittern, American Kestrel, Common Snipe, Greater Yellowlegs, Belted Kingfisher, Common Flicker, Pileated Woodpecker, Eastern Kingbird, Willow Flycatcher, Western Wood Peewee, Olive-sided Flycatcher, Tree Swallow, Barn Swallow, Common Crow, Cedar Waxwing, Red-eyed Vireo, Tennessee Warbler, Orange-crowned Warbler, Yellow Warbler, Northern Yellowthroat, Red-winged Blackbird, Brewer's Blackbird, Brown-headed Cowbird, Evening Grosbeak, White-crowned Sparrow, Lincoln's Sparrow and Song Sparrow. American Bittern, American Kestrel, Willow Flycatcher and Yellow Warbler are listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

Reptiles and Amphibians:

This ecosite includes ponds and wetlands that are very highly important breeding sites for Wood frog, Long-toed salamander and Western toad.

VL3

Ecoregion: montane
Landform: alluvial floodplain deposits
Vegetation: white spruce forest and wet shrub meadows

Ungulates:

This ecosite has similar importance for ungulates to VL1, high in winter and medium in summer. Forage use was recorded on river alder, swamp birch, red-osier dogwood, silverberry, hairy wildrye, *Hedysarum mackenzii*, prickly rose, willows (*Salix barclayii, candida* and *farrae*) and saskatoon.

Carnivores:

This ecosite is highly important, especially to wolf, coyote, cougar, weasel and lynx.

Small mammals:

Associations 1 and 4

The diversity and density of small mammals as well as the occurrence of bats, beavers and muskrats on this ecosite make it one of the most important ecosites for small mammals. There is a high number of species here and the varying hare, Columbian ground squirrel and red squirrel occur in high densities. This ecosite is very highly important for bats, beavers and muskrats, whose distribution is limited in the mountains.

Breeding birds:

Communities 5 and 9

A very high number of species occurs here at very high densities. This ecosite is highly important to the following species: Pileated Woodpecker, Western Wood Peewee, American Robin, Swainson's Thrush, Ruby-crowned Kinglet, Tennessee Warbler, Orange-crowned Warbler, Townsend's Warbler, Yellow Warbler, Wilson's Warbler Brown-headed Cowbird, Western Tanager, Dark-eyed Junco and White-crowned Sparrow. Yellow Warbler is listed on the 1981 Blue List of the

National Audubon Society (Tate 1981)

Reptiles and Amphibians:
This ecosite includes ponds and wetlands that are very highly important breeding sites for Wood frog, Long-toed salamander and Western toad

VL4

Ecoregion: montane
Landform: alluvial fans and floodplain deposits
Vegetation: white spruce forest
some balsam poplar stands

Ungulates:
Like VL3 this ecosite is highly important in winter and moderately important in summer. Forage use was similar to that recorded on VL3. Dense spruce forest on this ecosite provides important cover for wintering ungulates, particularly near developed areas.

Carnivores:
This ecosite is highly important to carnivores, especially to wolf, coyote, cougar and lynx.

Small mammals:
Association 1
The density of small mammals and the occurence of muskrats and the very rare pygmy shrew on this ecosite make it important for small mammals. A moderate number of species is found here. The dusky shrew, varying hare, red squirrel, deer mouse, red-backed role and western jumping mouse are present at high densities.

Breeding birds:
Community 5
A high number of species occurs here at very high densities. This ecosite is highly important to the following species: Ruffed Grouse, Alder Flycatcher, Common Crow, Mountain Chickadee, Boreal Chickadee, American Robin, Swainson's Thrush, Golden-crowned Kinglet, Solitary Vireo, Townsend's Warbler, Northern Waterthrush and Wilson's Warbler. Golden-crowned Kinglet is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

VL5

Ecoregion: montane
Landform: alluvial fans and floodplain deposits
Vegetation: wet shrub thickets
some balsam poplar stands

Ungulates:
This ecosite is highly important to ungulates year-round, particularly to moose and elk. Snow accumulation is low due to light snowfall and occasional thaws. Sedges, poplars (aspen and balsam), and bluegrass are important forage species on this ecosite.

Carnivores:
This ecosite is highly important to carnivores especially to wolf, coyote, cougar

and lynx.

Small mammals:

Association 4
A moderate number of species occurs here, with high densities of masked shrew, dusky shrew, varying hare, red squirrel and meadow vole. Little brown bats forage here.

Breeding birds:

Community 9
A high number of species occurs here at very high densities. This ecosite is highly important to the following species: Rufous Hummingbird, Least Flycatcher, Common Crow, Black-capped Chickadee, American Robin, Golden-crowned Kinglet, Warbling Vireo, Orange-crowned Warbler, Northern Waterthrush, Northern Yellowthroat American Redstart, Brown-headed Cowbird, Clay-coloured Sparrow and Lincoln's Sparrow. Golden-crowned Kinglet is listed on the 1981 Blue List of the National Audubon Society (Tate 1981).

WF1

Ecoregion: upper subalpine
Landform: colluvial slopes
Vegetation: spruce-fir forest
some larch-fir forest

Ungulates:

This ecosite is of low importance, although it is moderately important to moose. In winter snow depths of 1.0 m were recorded. Forage species on which use was recorded are Rocky Mountain rhododendron, willows (*Salix barratiana, glauca, vestita*), tall bilberry, grouseberry, and alpine bluegrass.

Carnivores:

This ecosite is of low importance to carnivores, being highly important only to marten.

Small mammals:

Associations 2,3 and 6
A high number of species occurs here, but none of these occurs at high densities.

Breeding birds:

Communities 7 and 8
A medium number of species occurs here at low densities. This ecosite is highly important to the following species: Ruby-crowned Kinglet and Pine Grosbeak.

WF2

Ecoregion: upper subalpine
Landform: colluvial slopes with active avalanching
Vegetation: avalanche shrubbery and meadows
patches of spruce-fir forest

Ungulates:

This ecosite is highly important to ungulates year-round although snow depths up to 1.4 m, too deep for most ungulates, have been recorded on some tracts in

mid-winter. More forage is available on tracts that have been avalanched, with use recorded on swamp birch, sedges, hairy wildrye, fireweed, Rocky Mountain fescue, *Hedysarum alpinum* and *sulphurescens*, bracted honeysuckle, bracted lousewort, timothy, bluegrass, shrubby cinquefoil, prickly rose, willows (*Salix arctica, barrattiana, glauca* and *vestita* and buffaloberry.

Carnivores:

This ecosite is moderately important to carnivores, notably wolverine, wolf and coyote.

Small mammals:

Associations 3 and 6

This ecosite supports few species. The pika, Columbian ground squirrel and golden-mantled ground squirrel occur in high densities.

Breeding birds:

Communities 7, 8, 10, 12 and 16

A medium number of species occurs here at low densities. This ecosite is highly important to the following species: White-tailed Ptarmigan and Townsend's Solitaire.

WF3

Ecoregion: upper subalpine
Landform: colluvial slopes with exposed rock faces
Vegetation: open coniferous forest
some bare rock

Ungulates:

This ecosite is highly important in winter, especially to mountain goat and bighorn sheep. In summer, the ecosite is moderately important to ungulates, being highly important to mountain goat and bighorn sheep. Snow depths are relatively shallow because of the steep south-facing, wind-blown slopes; maximum recorded snow depth was 0.4 m. Forage species include reed grass (*Calamagrostis rubescens*), Rocky Mountain fescue, junegrass, bluegrass and willows (*Salix barrattiana, glauca* and *vestita*).

Carnivores:

The importance of this ecosite to carnivores is low, partly because it is steep and relatively inaccessible.

Small mammals:

Associations 1 and 6

A low number of species is found on this ecosite. The yellow pine chipmunk and deer mouse occur in high densities.

Breeding birds:

Community 7

A low number of species occurs here at low densities. This ecosite is highly important to the following species: Townsend's Solitaire.

WF4

Ecoregion: upper subalpine
Landform: colluvial slopes
Vegetation: spruce-fir forest
patches of forb meadow

Ungulates:
In winter this ecosite is highly important and in summer it is very highly important, especially to deer, mountain goat and sheep. Forage species recorded include hairy wildrye, junegrass, bluegrass and willow.

Carnivores:
This ecosite is moderately important, especially to wolf, coyote, cougar and lynx.

Small mammals:
Association 1
A moderate number of species occurs on this ecosite. The bushy-tailed wood rat has been recorded here and the varying hare occurs at high densities.

Breeding birds:
Community 8
A low number of species occurs here at low densities. This ecosite is highly important to the following species: Common Flicker and Chipping Sparrow.

WF7

Ungulates:
This ecosite is very highly important to ungulates, combining forage and escape terrain. The ecosite is especially important to bighorn sheep and mountain goat. Dwarf birch, willows (*Salix barrattiana* and *glauca*), bluegrass and hairy wildrye are the forage species on which use was recorded here.

Carnivores:
The importance of this ecosite is low, although it is moderately important to wolf, coyote and cougar.

Small mammals:
Associations 1 and 7
A high number of species occurs here. The ecosite supports high densities of pikas and golden-mantled ground squirrels and very high densities of heather voles, meadow voles and long-tailed voles.

Breeding birds:
Communities 10 and 16
A medium number of species occurs here at low densities. This ecosite is highly important to the following species: Willow Ptarmigan and White-crowned Sparrow.

WH1

Ecoregion: upper subalpine
Landform: colluvial slopes
Vegetation: larch-fir forest

Ungulates:
This ecosite is of low importance. Forest cover and deep snow limits its usefulness to ungulates.

Carnivores:
This ecosite is of low importance, being highly important only to martens.

Small mammals:
Associations 2, 5 and 6
Although this ecosite supports a high number of species, only the heather vole is found in high densities.

Breeding birds:
Communities 7 and 8
A low number of species occurs here at low densities. Species of birds that occur here should be similar to those on WH2.

WH2

Ecoregion: upper subalpine
Landform: colluvial slopes
Vegetation: spruce-fir forest

Ungulates:
This ecosite is highly important to ungulates in autumn and winter but of low importance in summer. Avalanched tracts and forest clearings contribute to the importance of this ecosite although deep snow restricts winter use. Willows (*Salix glauca* and *vestita*) showed evidence of browsing on this ecosite.

Carnivores:
The importance of this ecosite to carnivores is low.

Small mammals:
Associations 3 and 6
This ecosite supports a high number of species but only the pika occurs in high densities.

Breeding birds:
Communities 7 and 8
A low number of species occurs here at medium densities. This ecosite is highly important to the following species: Blue Grouse, Boreal Chickadee, Hermit Thrush and Fox Sparrow.

WH3

Ecoregion: upper subalpine
Landform: colluvial slopes with active avalanching
Vegetation: avalanche shrubbery and meadows; spruce-fir forest stands

Ungulates:
This ecosite is generally of low importance to ungulates, although the mix of vegetation on avalanche slopes is highly productive of forage; some tracts are moderately or highly important.

Carnivores:
This ecosite is of low importance, although it is highly important to marten and moderately important to wolf, coyote and cougar in summer.

Small mammals:
Associations 1,3,6 and 7
This ecosite supports few species and high densities of pikas and hoary marmots.

Breeding birds:
Communities 7, 8, 10, 12 and 16
A low number of species occurs here at low densities. This ecosite is highly important to the following species: Blue Grouse, Brewer's Sparrow, White-crowned Sparrow and Fox Sparrow.

WH5

Ecoregion: upper subalpine
Landform: colluvial slopes with exposed rock faces
Vegetation: open coniferous forest
some open rock

Ungulates:
This ecosite is of low importance to ungulates. Snow depths of over 1.0 m were recorded; these would limit winter use by ungulates.

Carnivores:
The importance of this ecosite to carnivores is low.

Small mammals:
Association 6
There is a moderate number of species on this ecosite. There are high densities of pikas, hoary marmots and Columbian ground squirrels and very high densities of dusky shrews and heather voles.

Breeding birds:
Community 7
A medium number of species occurs here at medium densities. This ecosite is highly important to the following species: Gray Jay, Clark's Nutcracker, American Robin, Townsend's Solitaire and Bohemian Waxwing.

WW1

Ecoregion: lower subalpine
Landform: raw glacial till deposits
Vegetation: dryas mats
some young spruce and exposed till

Ungulates:
This ecosite is of low importance to ungulates. Scattered willows (*Salix glauca* and *vestita*) occur on some tracts and are browsed by elk and moose.

Carnivores:
This ecosite is moderately important, being highly important to marten and weasel and of moderate importance to other carnivores.

Small mammals:
Association 1

There is a moderate number of species on this ecosite. The golden-mantled ground squirrel and deer mouse occur in high densities.

Breeding birds:

Community 15
A low number of species occurs here at low densities. This ecosite is highly important to the following species: Killdeer and Spotted Sandpiper.

6.2. AQUATIC HABITAT DESCRIPTIONS

A requirement for integration of aquatic resources in the classification and mapping scheme of the Banff-Jasper biophysical land inventory was not included in the project's terms of reference. Consequently, lakes and ponds were mapped as miscellaneous units (W) and creeks and rivers were either mapped as miscellaneous units (SC) or not mapped, and treated as inclusions in terrestrial ecosites.

In order to adequately sample wildlife, however, it was necessary that these "... holes in the land... " (Welch 1978) be further differentiated in order to more adequately reflect habitat characteristics. The use of aquatic habitats by waterfowl, beaver, muskrats, carnivore species and moose varies markedly and it was felt that this variability should be quantified as much as possible.

Although aquatic wildlife use is frequently associated with alluvial ecosections such as the Vermilion Lakes, Hector and Num-ti-jah ecosections, many lakes, ponds and streams are too large to be considered inclusions or are isolated within the boundaries of other ecosections. In some cases aquatic features are associated with alluvial habitats but their shorelines or alluvial deposits are not sufficiently extensive to warrant mapping them at the 1:50,000 scale of mapping.

Methods

Because aquatic features were either un-mapped or mapped as miscellaneous units, it was decided that the aquatic habitat types would have to be broadly defined and based on easily recognized criteria. Welch (1978) describes a variety of approaches to classifying rivers and lakes but most of his approaches are tied by definition to mapping schemes. The approach we developed was both arbitrary and elementary (Table 6.1), bearing the greatest resemblance to Welch's description of genetic lake classifications (ibid. pg. 27) and river classification based on channel pattern (ibid. pg. 34).

This system is not based on equivalent criteria to those used in biophysical land classification, is not related to a mapping scheme, and is not a comprehensive classification of aquatic habitats. However it is felt that it gives a good first approximation of aquatic wildlife habitat and is included on that basis.

Table 6.1 Aquatic Habitat Classification (preliminary).

Aquatic Habitat	*Ecoregion*	*Characteristics*
AQ01	Montane	Lakes: alluvial
AQ02	Montane	Lakes: glacial till uplands
AQ03	Montane	Lakes: alluvial; seasonal water
AQ04	Lower Subalpine	Lakes
AQ05	Upper Subalpine	Lakes
AQ06	variable	Streams: aggrading, turbulent
AQ07	variable	Streams: aggrading, anastomose
AQ08	variable	Streams: degrading
AQ09	variable	Streams: stable
AQ10	Montane, Lower subalpine	Lakes: seasonal fluctuations
AQ12	variable	Reservoirs: artificial
AQ13	Subalpine	Lakes: glacial outwash

AQ01: Montane backwaters and floodplain lakes

Description

This aquatic habitat type is confined to the montane ecoregion in the middle and lower Athabasca River, middle and lower Bow River, and lower North Saskatchewan River valleys. It consists of overflow ponds, truncated meanders and other lakes and ponds associated with river floodplains. Many of these waterbodies are maintained by annual flooding in May and June when rivers overflow their banks and all respond to watertable changes in the alluvial areas. Ice breakup may be as early as mid-April, and freeze-up as late as mid-November.

Montane backwaters and floodplain lakes are frequently associated with the Vermilion Lakes ecosection and many ponds too small to be mapped, which would otherwise fit this category, are treated as inclusions within the Vermilion Lakes ecosection.

Ungulates

The importance of montane backwaters and floodplain lakes to ungulate is low. Potential importance for moose is high because of the abundance of *Potamageton* spp. and other favoured forage plants in these rich, shallow environments; however moose populations in the montane valleys where these waterbodies occur are depleted at present and use is consequently low.

Carnivores

Frozen montane backwaters and floodplain lakes are used in winter by wolves and, to a lesser extent, coyotes as travel routes and rendezvous areas. The abundance of muskrats and fish in these waterbodies creates a highly important habitat for mink, and otters formerly frequented Edna and Talbot Lakes.

Birds

Montane backwaters and floodplain lakes represent the most important habitat type in Banff and Jasper for migrating waterfowl. Extensive beds of emergent vegetation are used for feeding and cover, and submergent vegetation is relied upon for feeding. Abundant populations of suckers, whitefish, northern pike, trout and other fish provide food for loons, ospreys and Bald Eagles.

Species of waterfowl which rely upon montane backwaters and floodplain lakes during migration, and their numbers and migration phenology, are discussed in detail in section 4.3.2.

Small mammals

Beaver and muskrat frequent montane backwaters and floodplain lakes and beaver have dammed Talbot Lake and Vermilion Lakes, thus exerting a major influence on their water levels and extent.

AQ02: Montane kettles and scours

Desription

This aquatic habitat is confined to the montane ecoregion in the middle and lower Athabasca River, middle and lower Bow River, lower Cascade River, and lower North Saskatchewan River valleys. It consists of lakes and large ponds which have developed on upland sites and are not associated with floodplains of major streams. These may be kettle ponds, lakes dammed behind moraines, or lakes in hollows in ridged terrain. Most are fed and drained by small streams but others, such as Lac Beauvert, are fed primarily by underwater springs. Ice breakup is in late April and May, and freeze-up is in November.

Montane kettles and scours are associated with a number of land systems but particularly with the Patricia ecosection. Some examples include Johnson Lake and Pilot Pond in Banff, and Patricia and Pyramid Lakes, Lakes Edith and Annette, and the lakes of the Pyramid Bench in Jasper.

Ungulates

The importance of montane kettles and scours to ungulates is low. It was not possible to measure use by moose since our sampling was based on pellet group counts, however it is potentially low, since pondweed growth is much lower here than in montane backwaters and floodplain lakes.

Carnivores

Frozen montane kettles and scours are used in winter by wolves and coyotes as travel routes and rendezvous areas. Mink are present.

Birds

Although less important to waterfowl than montane backwaters and floodplain lakes and the Vermilion Lakes ecosection, montane kettles and scours are a highly important habitat for migratory waterfowl. Oldsquaw, White-winged Scoter and Surf Scoter occur regularly on Pyramid and Patricia Lakes during late April and early May, and Red-necked Grebes nest on Patricia Lake, which is one of only two known nest locations in Banff and Jasper.

Montane kettles and scours support the bulk of Banff and Jasper's breeding Common Loon population.

Small mammals

Beavers are present in some montane kettles and scours, however the limited extent of associated alluvial deposits restricts the potential of these areas for beavers since willows and poplars, major food plants, are generally confined to alluvium. Montane kettles and scours with marshy shorelines or stream deltas, such as Patricia Lake, are more important to beavers than isolated ponds such as Pilot Pond.

AQ03: Jasper Lake

Description

Jasper Lake is a unique habitat in Banff and Jasper. Similar lakes exist adjacent to but outside Banff and Jasper, at Lac des Arcs and Brule Lake. Jasper Lake is an extensive silt bed upstream along the Athabasca River from the fans of the Snake Indian River and Rocky River. During the high water period of June to August this widening in the river becomes a wide shallow lake, but as the river drops in late summer the silt beds become exposed until Jasper Lake is only an expanse of exposed mud with the river winding in a narrow channel through the middle.

Jasper Lake is the major source of the wind-blown material which is responsible for the Devona ecosection and the Talbot ecosection, and is surrounded by ecosites of these ecosections.

Ungulates

The importance of this aquatic habitat type to ungulates is low. It is not used by moose and the only ungulates that have been observed crossing it are elk, on 2 occasions.

Carnivores

In winter Jasper Lake is used as a travel route by wolves. It is not important to other carnivores.

Birds

There is only limited use of Jasper Lake by waterfowl. Migrating American Wigeon, Mallard and teal gather at the outlet of Jasper Lake in mid April and May and again in September, and up to 10 Ring-billed Gulls have been recorded where the outlet stream of Edna Lake enters Jasper Lake.

Small numbers of several species of shorebirds use the sandy beaches along the north and east sides of Jasper Lake. These include Buff-breasted Sandpiper, Baird's Sandpiper and Semipalmated Plover. Ospreys and Common Loons make very low use of Jasper Lake.

Management

Although Jasper Lake is of low short-term importance to most species of wildlife, interruptions of its normal water regime could adversely affect its ability to accumulate silt which is later picked up by wind and deposited in dunes and veneers on the surrounding landscape. The loess-derived ecosections associated with Jasper Lake have high importance to wildlife.

AQ04: Lower subalpine lakes

Description

This aquatic habitat type occurs in the lower subalpine ecoregion throughout Banff and Jasper. It includes all lakes and large ponds in this ecoregion, most of which are on upland sites and are not associated with floodplains of major streams, the most notable exception being the Snake Indian Lakes in northern Jasper. Breakup is in May or June and freeze-up is in October or November.

Lower subalpine lakes are associated with a variety of terrestrial ecosections, usually having at least part of their shorelines adjoining units of the Hector ecosection and the Pipestone ecosection. Some examples of lower subalpine lakes include Wigmore Lake, Lake Louise, Bow, Peyto and Waterfowl Lakes, Maligne Lake and Jacques Lake.

Ungulates

The importance of lower subalpine lakes to ungulates is low. Moose forage in these water bodies in sites when submergent vegetation is available; most notably in Upper Waterfowl Lake and Snake Indian Lakes.

Carnivores

Wolves and coyotes use frozen lower subalpine lakes in winter as travel routes. Lower subalpine lakes with adequate fish populations and marshy shorelines are moderately important to mink. A family of mink was seen at Beaver Lake in 1977 (DBD) and another at Maligne Lake in 1954 (LAM, Jasper warden card).

Birds

Lower subalpine lakes are moderately important to waterfowl. Migrant species which use these waterbodies include Mallard, Green-winged Teal, Barrow's Goldeneye and Harlequin Duck. Only Maligne Lake receives regular use by ospreys.

Small mammals

Beaver and muskrats are uncommon in lower subalpine lakes because of the lack of food plants and shelter. Both species are present at Wigmore Lake, Waterfowl Lakes and Snake Indian Lakes where adjacent willow stands and lake edge sedge beds provide the needed habitat requirements.

AQ05: Upper subalpine and alpine lakes

Description

This aquatic habitat type includes all lakes and large ponds in the upper subalpine and alpine ecoregion throughout Banff and Jasper. Breakup is in late May or June and freeze-up is in October.

Upper subalpine and alpine lakes are associated with a variety of terrestrial ecosections. Some examples of upper subalpine and alpine lakes include Redoubt, Baker and Ptarmigan Lakes, Helen Lake, Sunwapta Lake, Amethyst Lakes and Miette and Azure Lakes.

Ungulates

Upper subalpine and alpine lakes are not important to ungulates.

Carnivores

Mink have been observed at Amethyst Lakes where they were believed to be feeding on spawning rainbow trout (July 1978, KVT), however most upper subalpine and alpine lakes are not sufficiently productive to support this species.

Birds

Upper subalpine and alpine lakes are of low importance to birds. Ospreys have been observed at Amethyst Lakes, but the low productivity of these high-elevation waterbodies, coupled with the short span of their ice-free period, is limiting to most bird species.

Small mammals

Upper subalpine and alpine lakes are not important to beaver, muskrat or other rodent species.

AQ06: Aggrading whitewater rivers

Description

This aquatic habitat type occurs in all ecoregions except the alpine and is commonest in the subalpine. It includes reaches of most major rivers where the water flows mostly through a single very turbulent channel in a gravelly floodplain which floods yearly. Because of the turbulence parts of these reaches may remain ice-free all winter.

Aggrading whitewater rivers are commonly not associated with alluvial ecosections, but flow between steep valley slopes or series of tributary alluvial fans (PP1, PP3, AL1, AL2, MQ1). Some examples include the Bow River upstream from Lake Louise service centre, the Mistaya River below Peyto Lake, the Athabasca River below the Whirlpool River confluence, and the Snake Indian River.

Ungulate

This aquatic habitat is of low importance to ungulates. Willows that grow in the gravel bars and deposits are browsed by moose, deer and elk.

Carnivores

This habitat is generally of low importance to carnivores, however high track counts of mink along the Alexandra River in the winter of 1979/80 were associated with open water in the turbulent stream.

Birds

Aggrading whitewater rivers are important to Harlequin Ducks in summer and to American Dippers on a year round basis.

Small Mammals

Aggrading whitewater rivers are not important to small mammals.

AQ07: Aggrading braided rivers

Description

This aquatic habitat occurs in all ecoregions except the alpine. It includes reaches of most major rivers, especially those which derive from large glaciers that provide large amounts of sediment. They have a shallower gradient and heavier sediment load than aggrading whitewater rivers. These river reaches consist of numerous small channels flowing rapidly over broad expanses of gravel and sand. Annual flooding frequently results in changes in the patterns of the channels and inhibits vegetation from developing beyond early successional stages on the floodplain.

Aggrading braided rivers are most commonly associated with PP4 and are usually mapped as SC (stream channel). Other ecosites with which this aquatic habit is frequently associated include HC1, HC4, PP1, PP3, and VL1. Some examples of aggrading braided rivers include Bath Creek south of the trans-Canada highway, much of the Howse River and Alexandra River, Graveyard flats on the upper North Saskatchewan River, Beauty Creek flats on the Sunwapta River, and Scott Creek.

Ungulates

This aquatic habitat is not important to ungulates.

Carnivores

This aquatic habitat is not important to carnivores although in winter the frozen channels and gravel flats may be used by wolves for travelling.

Birds

Spotted Sandpipers and Killdeers are present but this habitat is not otherwise important to birds.

Small mammals

This habitat is not important to beavers, muskrats or other small mammals.

AQ08: Degrading (gorge and waterfall) rivers

This aquatic habitat is of limited extent in Banff and Jasper and occurs in all ecoregions and watersheds. It includes reaches of rivers and streams that are dropping in elevation so rapidly that they have eroded canyons through rock, filled with waterfalls, chutes and plunge pools. A common location for this aquatic habitat is where a tributary stream is degrading rapidly to the level of a larger stream in a major valley.

Degrading (gorge and waterfall) rivers are associated with a variety of terrestrial ecosections. Some examples include Johnston Canyon, Mistaya Canyon, Sunwapta Canyon, Sunwapta and Athabasca Falls, Maligne Canyon, and Snake Indian Falls.

Ungulates

This aquatic habitat is not important to ungulates.

Carnivores

This aquatic habitat is not important to carnivores.

Birds

This aquatic habitat is important for nesting and wintering American Dippers, nesting Common Ravens, and particularly for Black Swifts. There are only 2, or possibly 3, nesting colonies of this species in Banff and Jasper, all in canyons.

Small mammals

The rocky walls of the canyons are important breeding habitat for Bushy-tailed wood rats.

AQ09: Stable (pool and riffle) rivers

Desription

This aquatic habitat type occurs in the montane and lower subalpine ecoregions. It includes reaches of most major rivers where the water flows from pool to pool through riffles and small rapids. The floodplain is mostly vegetated, with gravel or mud point bars, and the river meanders in a single main channel.

Stable (pool and riffle) rivers are associated with the VL ecosection, the HC ecosection, the HD ecosection and the PP ecosection. Some examples include the Bow River between Eisenhower function and Banff townsite, the Mistaya River below Waterfowl Lakes, the Athabasca River downstream from Jasper townsite, and the middle Snake Indian River.

Ungulates

This aquatic habitat type is not important to ungulates.

Carnivores

Stable (pool and riffle) rivers are of moderate importance to mink and potentially important to otter, which occurred along the lower Athabasca River until 1969. Wolves and coyotes use frozen stable (pool and riffle) rivers in winter as travel routes.

Birds

Stable (pool and riffle) rivers are of high importance to Common Merganser, Harlequin Duck, Spotted Sandpiper, Belted Kingfisher and American Dipper. Migrating waterfowl make moderate use of this habitat and, where patches of water remain unfrozen during much of the winter, Mallard and Common Goldeneye occasionally remain all year long.

Small mammals

Stable (pool and riffle) rivers are moderately important to beaver, which build bank dens and lodges along the banks in the slower reaches of the Bow River, Mistaya River, Athabasca River, Miette River and Snake Indian River.

AQ11: Medicine Lake and Lake Minnewanka

Description

Medicine Lake and Lake Minnewanka are unique in that they are subject to extreme fluctuations in water levels. Lake Minnewanka is a hydroelectric reservoir in the montane ecoregion which rises and falls in response to drawdowns for power generation and is fullest in autumn. Medicine Lake is drained by sinkholes in the lake bed and is only bankfull for a brief period in July and August after the spring flood. During winter only the lower half of the lake remains full.

Ungulates

Medicine Lake and Lake Minnewanka are not important to ungulates except Medicine Lake which is of high importance to Woodland caribou in May and June, when they feed on sedge beds on the delta at the upper end of the lake.

Carnivores

Medicine Lake and Lake Minnewanka are of no importance to carnivores although wolves and coyotes use the frozen lake surfaces in winter.

Birds

Medicine Lake and Lake Minnewanka are of moderate importance to migrating waterfowl, especially Mallards, Barrow's Goldeneyes, Common Goldeneyes and Lesser Scaups. There is an osprey nest at Medicine Lake.

Small mammals

Medicine Lake and Lake Minnewanka are not important to beavers or muskrats.

AQ12: Sewage lagoons and other man-made waterbodies

Description

Sewage lagoons and other man-made waterbodies are mostly confined to the montane and lower subalpine ecoregions. Besides sewage lagoons, other man-made waterbodies include flooded borrow pits, which can be seen adjacent to highway 1; water impoundments such as the one at Cabin Lake and the one on Fortymile Creek; and flooded ditches. Because AQ12 includes a variety of kinds of waterbodies, wildlife use is variable.

Ungulates

Flooded borrow pits and ditches can be of moderate to high importance to elk when they support growths of sedge and willow. Otherwise, sewage lagoons and other man-made waterbodies is not important to ungulates.

Carnivores

Sewage lagoons and other man-made waterbodies are not important to carnivores.

Birds

The sewage lagoons at Jasper townsite are of moderate importance to migrating waterfowl and shorebirds. Because they remain partly unfrozen in winter they are used by over-wintering Mallards and a Song Sparrow was recorded there on 16 December, 1979 (KVT). Other man-made waterbodies are of low importance.

Small mammals

Sewage lagoons and other man-made waterbodies are not important to small mammals.

AQ13: Glacial outwash lakes

Description

This aquatic habitat type occurs in the subalpine and alpine ecoregions on the outwash plains of glaciers. It includes lakes and ponds fed by glacial meltwater and dammed by terminal moraines or rock ridges. There is both daily and annual fluctuation of water levels in response to changes in the rate of melting of the glaciers. Some examples of glacial outwash lakes include Cauldron Lake and Sunwapta Lake.

Ungulates

Glacial outwash lakes are not important to ungulates.

Carnivores

Glacial outwash lakes are not important to carnivores.

Birds

Glacial outwash lakes are of low importance to Spotted Sandpipers and Killdeers, but are not important to other bird species.

Small mammals

Glacial outwash lakes are not important to small mammals.

7. WATERSHED ACCOUNTS

The following watershed accounts:

1. Provide a general description of the various parts of Banff and Jasper National Parks from a geographical standpoint.
2. Present general distribution data on species, particularly large mammals, which have traditional seasonal ranges which do not directly correspond to the ecological land classification.
3. Identify site-specific or watershed-specific wildlife values or management issues.

Parks Canada has divided Banff and Jasper into 26 and 34 watersheds respectively to facilitate computer storage and retrieval of wildlife observations. For the purpose of our watershed accounts we have used the same watershed boundaries but have lumped two or more watersheds in some cases to make our accounts more manageable or more comprehensive (Figure 1.1, 1.2).

Each watershed account is in three parts. The first is a general description of terrain and vegetation, developments and any outstanding habitat features such as extensive burns, major wetlands or significant montane or alpine areas. The second describes wildlife use beginning with ungulates; then carnivores; then small mammals, birds and herpetiles. Emphasis is placed on seasonal ranges, geographical distribution and historical status. Specific habitat data and other information dealt with in species accounts were excluded and the user is encouraged to refer to species accounts where necessary. The third part describes any watershed- specific management issues and recommendations with regard to wildlife and habitat management.

The organization of watershed accounts is basically from south to north, with the most intensively-developed watersheds dealt with before more remote ones.

LOWER BOW RIVER WATERSHED

The lower Bow River watershed lies entirely within the Front Ranges of Banff (Figure 1.1).

This is the most extensively developed watershed in Banff and Jasper. It contains a golf course, a townsite, airstrip, rodeo grounds, 900-site campground, hot spring development, landfill, several scenic drives and a buffalo paddock, and will soon have a four-lane divided highway. At least 10% of the montane portion of the lower Bow River watershed has been developed for human uses (Holroyd and Markel unpub. data).

The Bow River flows from west to east in a narrow floodplain except for the 5 km. reach upstream from Banff townsite where the large alluvial fans of Fortymile Creek and the Spray River dammed the valley and created an extensive backswamp area which includes the Vermilion Lakes and Cave and Basin ponds. The only other large alluvial fan, at the mouth of Carrot Creek, does not block the valley but does create a widening in the Bow River. There are small wetlands west of the Carrot Creek fan and south of the trans-Canada highway.

Table 7.1. Ungulate mineral licks recorded in Banff National Park.

	Location	*U.T.M.*	*Watershed*	*Ecosite*	*Species*
1	Dormer River	PH013027	Panther	WF03	Sheep, goats, elk
2	Red Deer River and McConnell Creek Junction	NH763234	Red Deer-M	PP07	Sheep
3	Flints Peak - Cascade Valley	NG878978	Cascade-U	SB04	Elk, sheep, goats
4	Mi 4 Cascade Road, northeast end of bridge	PG023827	Cascade-I	PR06	Sheep
5	3rd Vermilion Lake (north shore)	NH957702	Bow-L	NY03	Sheep
6	Siffleur River - west of Clearwater Pass	NH488302	Siffleur	NT02	Sheep
7	Near Healy Creek Warden Cabin	NG847641	Healy	SB01	Sheep
8	Sunshine Road	NG862631	Healy	WF03	Sheep
9	Just west of Tyrell Creek near Red Deer River	NH842255	Red Deer-M	GT02	Elk
10	Red Deer River between Tyrell Creek & Divide Creek	NH824247	Red Deer-M	GT02	Sheep
11	Near lake southwest of Prow Mountain - at creek	NH794193	Red Deer-M	NT02	Elk
12	Upper Divide Creek	NH755307	Red Deer-M	CN01	Elk
13	South of Gable Mountain near Panther River	NH905153	Panther	GT02	Mule
14	Southwest of Gable Mountain	NH886198	Panther	SX02	Elk
15	Southwest of Mount Kentigern	NH441354	Siffleur	CV01	Elk
16	East side of Silverhorn Mtn.	NH358346	Siffleur	MP01	Caribou
17	Saskatchewan crossing	NH199576	N. Sask.-L	TA03	Moose
18	West of Dormer Warden Cabin	NH984026	Panther	SX01	Elk
19	Cuthead Creek	NG910989	Cascade-M	PR02	Elk
20	On unnamed creek west of Wigmore Creek	NH883050	Panther	SX03	Elk, moose
21	8 Mi Creek, near Spray River	PG039606	Spray-L	PR02	Sheep, goats
22	N. Sundance (Bourgeau) Range	NG962631	Bow-L	WF03	Sheep
23	Upper Carrot Creek	PG159729	Bow-L	GT02	Elk
24	Viewpoint on trans-Canada hwy (above 2nd Vermilion Lake)*	NG975706	Bow-L	NY01	Sheep
25	Indianhead Creek near Clearwater River	NH692439	Clearwater	PP03	Moose
26	Lake Minnewanka Bridge*	PG058780	Cascade-L	AT02	Sheep
27	Snow Creek	NH858129	Panther	HC04	Elk
28	Indianhead Creek	NH623490	Clearwater	NT02	Unspecified

* Roadside licks

Table 7.2. Ungulate mineral licks recorded in Jasper National Park.

	Location	*U.T.M.*	*Watershed*	*Ecosite*	*Species*
1	East gate*	MJ447973	Athab-L	HD01	Sheep
2	S.end of Roche Ronde	MJ340960	Athab-L	TA02	Sheep, goats
3	Old Lime Kiln	MJ353920	Athab-L	TA02	Elk, sheep, goats
4	Disaster Point	MJ355905	Athab-L	TA02	Goats, sheep
5	Devona	MJ323897	Athab-L	TA02	Goats, sheep
6	Edna Lake	MJ308807	Athab-L	TA03	Goats
7	Cold Sulphur Springs	MJ275775	Athab-L	TA02	Sheep, caribou, mule deer
8	Morro Point*	MJ272772	Athab-L	VL01	Goats, sheep, mule deer
9	Near Mile 3 Bridge	MJ288628	Townsite	NY02	Sheep
10	Goat Viewpoint	MJ426299	Athab-U	NY03	Goats, elk
11	Lick Creek (Fryatt Creek)	MJ438276	Athab-U	NV03	Goats, elk
12	Shalebanks	MJ193989	Snake-L	NY03	Sheep, goats, elk, deer, moose
13	Snake Indian Falls	MK153055	Snake-L	NY03	Sheep
14	Near Seldom Inn	MK128074	Snake-L	PR04	Sheep
15	Junction of Blue Creek and Snake Indian River	LK907105	Snake-L	TZ01	Elk, deer
16	Twintree Creek	LK662115	Smoky	SX01	Caribou
17	Miette Hotsprings area	MJ482868	Sulphur	PR04	Sheep
18	Rocky River	MJ446765	Rocky-L	PR06	Goat
19	Maligne Road*	MJ555448	Maligne-M	BV01	Caribou, mule deer
20	Middle fork of Southest River	MJ879293	Southesk	HC04	Elk, deer
21	Poligne Creek, Poboktan Creek Junction	MJ752128	Poboktan	PR03	Mule
22	Middle Whirlpool River	MJ223206	Whirlpool	BY02	Goat
23	Miette River	MJ055608	Miette	NY03	Elk
24	Along canyon rim Brazeau River upstream from Arete cabin	NJ060114	Brazeau-L	BK04	Sheep

* Roadside licks

Figure 7.1. Locations of mineral licks in Banff National Park.

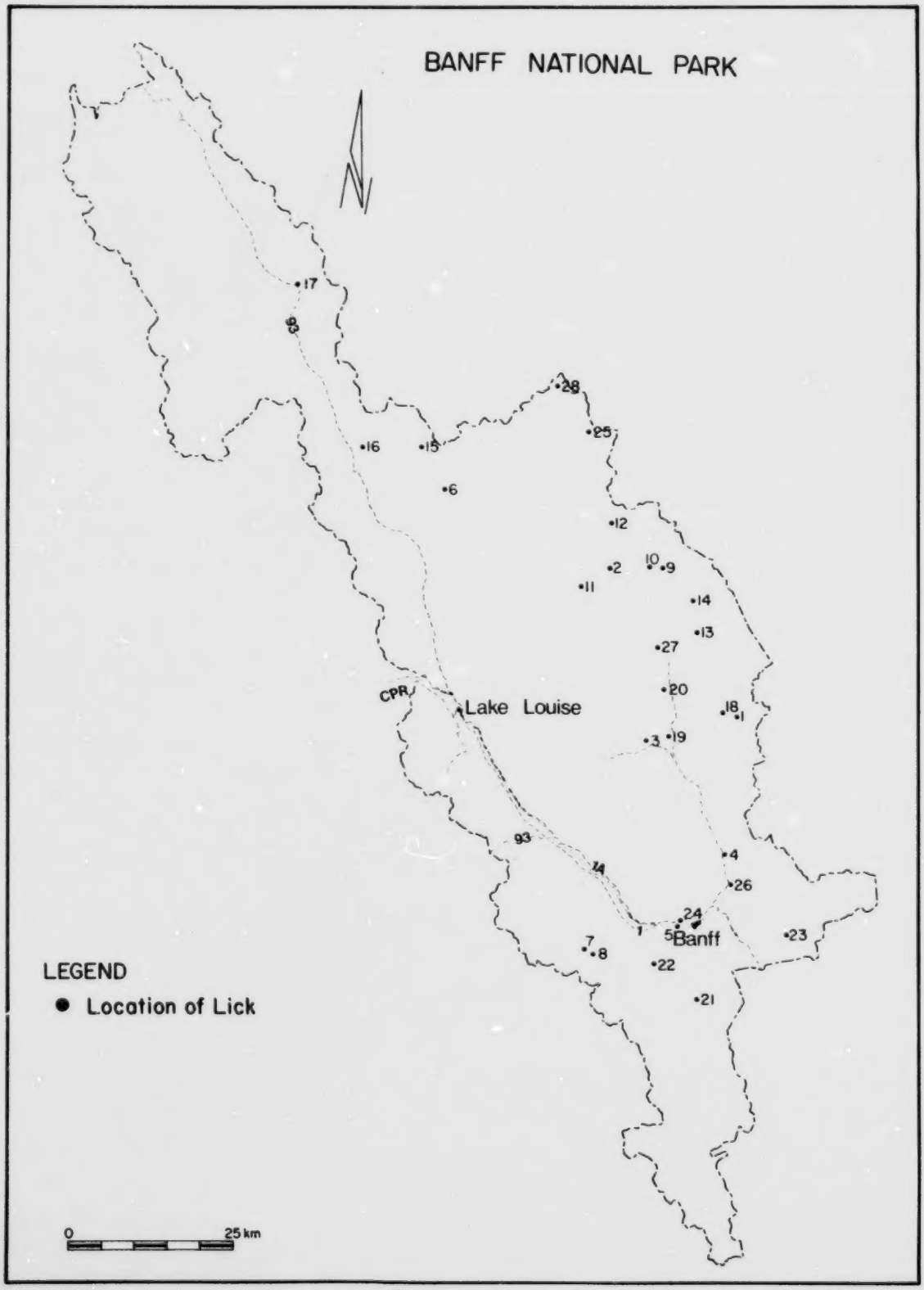
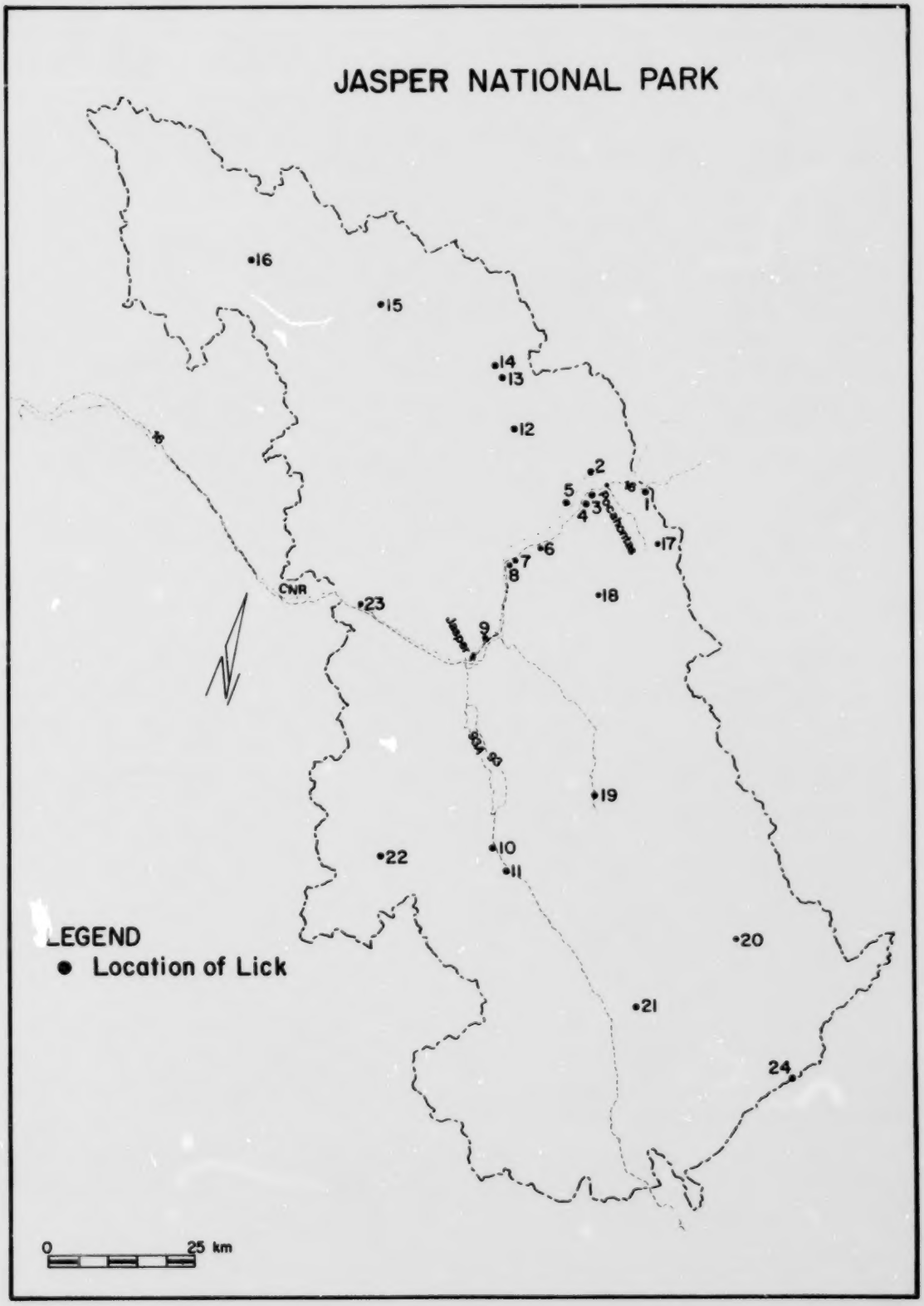


Figure 7.2. Locations of mineral licks in Jasper National Park.



An extensive aspen forest on the Carrot Creek fan is succeeding gradually to white spruce; this and a stand of aspen in the buffalo paddocks are the only extensive stands of aspen in the lower Bow River valley. Scattered smaller stands occur elsewhere on alluvial fans and the floodplain of the river, and on the terraces of glacial till along the north side of the valley.

Lodgepole pine forest predominates on the extensive glacial till terraces and slopes on both sides of the valley. There are also several stands of Douglas fir/hairy wild rye (C1) forest on the south facing slopes of the valley; this rare habitat is confined in Banff to the Bow River and lower North Saskatchewan River valleys.

There are small grasslands on the alluvial fans of Fortymile Creek and the lower Cascade River. These are naturally occurring grasslands which were probably formerly maintained by fire but are now being encroached upon by aspen and white spruce.

Mature white spruce forest or mixed white spruce/balsam poplar forest is rare in the lower Bow River valley, being restricted to the Vermilion Lakes area and isolated pockets along the river floodplain.

The steep north-facing slopes of Mt. Rundle and Sulphur Mountain are heavily forested with spruce/fir forest, while the more exposed southerly slopes of Mounts Norquay and Stoney Squaw, Cascade mountain and Mounts Inglismaldie, Peechee and Princess Margaret are clothed with open spruce and mixed coniferous forest, with many open slopes dominated by bearberry and grasses.

The Vermilion Lakes area is a complex mosaic of lakes, channels, sedge meadows, willow bogs and while spruce forest which is more fully described in a study by the Bow Valley Naturalists (1978).

Wildlife

The lower Bow River watershed is used by every species of ungulate occurring in Banff, except Woodland caribou. It includes a major winter range for elk and mule deer and is also used in winter by bighorn sheep. Moose and mountain goat are uncommon.

Bighorn sheep occur in all the mountain of the lower Bow River drainage and park visitors regularly watch them on Mount Norquay and the top of Sulphur Mountain. They are rare on Mt. Rundle and their status on the Fairholme Range is poorly known.

Above the Vermilion Lakes the slopes of Mt. Norquay are important to sheep which winter along the SW side of the Sawback Range. In the 1920's the Sawback-Norquay range supported up to 375 sheep, with the animals grazing on open grasslands of fire origin (Hewitt 1921). By 1958 (Banfield) the south end of the Sawback was thickly covered with young Douglas fir. The open, grassy areas created by the highway have become important range for the present wintering population of 35 to 40 sheep. Highway- related deaths are as much a factor in the decline of this population to its present level as is forest succession on the formerly more extensive meadows of the Sawback Range. In 1979, 14 sheep died on the highway above the Vermilion Lakes (Flygare 1979).

The area from Fortymile Creek to the park gates is a higly important winter ungulate range. More than 40% of all highway mortality of ungulates in Banff occurs here. Grassland areas on the Fortymile Creek fan and at Duthill are highly important elk winter range which are becoming more important as forest encroaches on fire-origin ranges elsewhere in the watershed.

From the time of the arrival of the railroad until the early twentieth century numerous fires burned in the lower Bow valley, creating a great amount of good ungulate range. By this time, however, there were few ungulates left due to hunting pressure from miners, prospectors, early settlers, and the Stoney Indians. Disease and severe

winters in 1886, 1887 and 1906 led to the complete extirpation of elk. In 1919-1920 141 elk were released at Duthill and 53 near Massive. By the 1940's the descendants of these elk had spread to all the parts of Banff where they occur today (see Elk species account above). The extensive fire-origin ranges led to a population explosion of elk in the 1940's and necessitated controlled slaughters to prevent permanent damage to the range. The maturing of these fire successional forests has resulted in a steady decline in the extent and quality of ungulate range since the middle of the century.

Since the late 1950's the trans-Canada highway, with its wide, seeded margins, has compensated to some extent for this loss of range; the compensation, however, has proven to be a two-sided coin. Between 1966 and 1980 inclusive, 321 elk were killed by vehicles on this stretch of highway 1 (Flygare 1979).

Mule deer winter in the lower Bow River valley on forested south-facing slopes and the slopes of Tunnel Mountain, as well as along the edges of the Bow River floodplain. Although moose were formerly common in the Vermilion Lakes area, with at least 10 present there in the 1940's (Green 1955), they are uncommon now, with probably fewer than 10 in the whole lower Bow River watershed. Forest succession and mortality on the CPR railroad have contributed to their decline. Although white-tailed deer are rarely seen, the lower Bow River is one of the few parts of Banff and Jasper where they occur regularly in small numbers.

The abundance of wintering ungulates and the productivity of some of the alluvial habitats for small mammals create a high potential for carnivores in the lower Bow River watershed, however the intensity of human use of the area limits this potential for the larger carnivores such as wolf and cougar.

Cougars were formerly more common in the lower Bow River watershed. Between 1930 and 1937 there were 28 cougars killed by park wardens and professional cougar hunters in Banff, most of them in the Bow River area. At present there are very few cougars in the area and it is doubtful that there is a resident population. Similarly, wolves were present in the lower Bow River drainage during the first half of this century, with two packs totalling 7 to 9 animals denning in the Bow River drainage and ranging at least as far downstream as Vermilion Lakes. Following their near elimination by poisoning in the 1950's wolves never became re-established in the Bow valley, probably because of the extent of human disturbance in the area. Recently there have been 4 unverified sightings from near Anthracite and Carrot Creek and in January 1982 a wolf was killed by a car on the Trans Canada highway near the Cascade power house (park wildlife cards).

Coyotes, on the other hand, are more abundant in the lower Bow River drainage than anywhere else in Banff and Jasper. A winter track transect index of 3.0 tracks/10 km-days was recorded in the lower Bow River valley, this being more than twice as great as the next most important area, the vicinity of Jasper townsite. The ongoing availability of rodents and of road and train-killed carrion, combined with the presence until 1980 of an open garbage landfill, account for the density of coyotes in this area. Possibly the lack of wolves enables coyotes to occupy a somewhat broader niche than they do in otherwise similar habitats in the lower Athabasca River valley.

Mink are common around the Vermilion Lakes and elsewhere in the lower Bow River watershed. Marten are uncommon, having been recorded on winter tracking transects at a rate of 1.3 tracks/10km-day, and weasels are fairly common.

Black and grizzly bears have traditionally fed at the Banff sanitary landfill and the former species is reported regularly in town. The town's garbage has been an ongoing drain on the lower Bow River watershed's black bear population as most troublesome garbage bears are ultimately killed (species accounts, above). It is unlikely that the lower Bow River valley sustains a stable population of Black bears; most records are of juveniles which have dispersed into the valley from outlying areas.

The habitat diversity of the lower Bow River watershed, combined with the large extent of the montane ecoregion in the area, contributes to the diversity and abundance of the area's avifauna. The Vermilion Lakes area, in particular, is of exceptional importance to a wide variety of birds including the only nesting Bald Eagles and Red-necked Grebes in Banff (see species accounts).

Montane wetlands of this watershed provide good habitat for shrews, bats, beaver and muskrats. Beavers occur in several locations including Vermilion lakes, Echo and Fortymile Creek, Chinaman's Creek (at Anthracite), Sundance Creek, the Bow River and ponds of the Carrot Creek fan. In 1944 Hubert Green of the Banff Warden Service, prepared a report on beaver in the Bow valley and estimated the population as follows:

Lower Fortymile area: 30
Echo Creek area: 27
Vermilion area: 96
Sundance area: 66

In 1956 Warden Ferris surveyed beavers in some of the same areas and estimated the beaver population at 105 animals for the lower Bow River watershed. Beavers are probably now as common as they have ever been. Muskrats are very common in wetland areas, though the number of pushups observed in the autumn at Vermilion Lakes fluctuates from year to year.

Management

The montane ecoregion comprises only 2.9% of Banff National Park's land area and of this 77.4% is in the Bow River valley, where the vast bulk of Banff's human facilities are concentrated. The very high importance of the montane ecoregion to wildlife, its limited extent and the concentration of developments here create numerous management problems and conflicts. The aspen forests and grasslands of the lower Bow River valley have been more extensively developed (approximately 25%) than other montane vegetation types; ironically these are among the most highly important and limited in distribution.

Further incremental loss of grassland, aspen forest and Douglas-fir forest can be anticipated and will have major impacts on the ability of the lower Bow River valley to sustain ungulate populations and other wildlife. In 1981, for example, a weather station was placed in one of the last remaining grasslands in the Bow valley, followed by a series of well-sites for the townsite water supply. In 1982 there was a proposal to build a new hospital on part of same grassland. Phase II of the Trans-Canada highway twinning will remove more of this grassland. The rarity and importance of these montane habitats renders their development contrary to the Parks Canada preservation mandate. Any impact from habitat loss or unnatural mortality on ungulates wintering in the lower Bow River valley will be felt in a much larger area of the park since ungulates likely migrate from several watersheds to winter here.

Development of the montane ecoregion has far greater overall consequences to wildlife, generally, than development in the subalpine ecoregion. It is unlikely that Banff townsite or other facilities in the lower Bow River watershed can expand without further wildlife losses.

The Vermilion Lakes and their associated wetlands are important as wildlife habitat and as recreational and nature interpretation areas. Historically the area has been subject to a great deal of manipulation. In 1884 a railway bisected the wetlands. During the early 1900's cattle were grazed there and the meadows were cultivated and mowed. Mosquito control with DDT took place in the early part of the century. The construction of the Trans-Canada highway in the 1950's destroyed a natural hotspring at Third Lake and in the 1960's an earthen dam was built at the lake outlet to raise the water level. Beavers have since dammed the outlet and raised the water to its highest levels in many years.

In spite of a long history of changes and heavy recreational use at present, Vermilion Lakes continues to be important habitat for a number of species of wildlife that occur only rarely or nowhere else in the park. The absence of nesting Common Loons, the rarity of moose and the long absence of wolves from the area, however, indicate that this is an ecosystem under stress. Management of the lakes and their recreational use by wind-surfers, boaters and fishermen, will continue to limit use of this valuable area by sensitive wildlife species.

Highway mortality is higher in the lower Bow River valley than anywhere else in Banff. This is a consequence both of the high concentrations of ungulates here, especially in winter, and the volume of traffic. Flygare (1979) analyzed highway and railroad mortality in depth and Holroyd (1979) indicated that unnatural mortality alone may account for ongoing declines of elk and moose. Fencing and construction of underpasses and other such structures along the twinned Trans-Canada highway may reduce the amount of highway mortality in the area. Controlled burns may also alleviate the problem to some extent by creating high quality habitat away from the roadsides.

MIDDLE BOW RIVER WATERSHED

Including as it does the broad montane and upper subalpine valley bottom of the Bow River, extensive side valley systems, and parts of both the Main and Front Ranges, this is a diverse and complex watershed (Figure 1.1). The predominant vegetation of the Bow River valley is lodgepole pine forest. The numerous dense, even-aged stands on the glaciofluvial terraces and till deposits of the valley attest to the extent to which this valley was burned during the railroad-building days of the 1880's and the highway building days of the early 1900's.

Numerous gravel borrow pits and the wide road and railroad rights of way create openings in this forested terrain. In addition, there is a natural grassland on the large alluvial fan at Hillsdale and several shrubby meadows near Muleshoe, Johnston Canyon and Eldon siding. On the south and southwest-facing slopes of the Sawback Range and Castle Mountain there are extensive colluvial grasslands which are being invaded by aspen, spruce and Douglas-fir.

There are extensive aspen forests between Hillsdale and Muleshoe on south-facing alluvial fans, as well as numerous smaller stands of aspen, balsam poplar, or mixed forest along the lower slopes and valley floor.

The valleys of Wolverine, Redearth, Bourgeau, Moraine and Louise Creeks are typical subalpine creek valleys with alluvial herb, shrub meadows and open forest along their bottoms, and Engelmann spruce-subalpine fir forests on the slopes, dissected by avalanche paths in many places. These valleys descend out of the Main Ranges and are consequently moister and accumulate more snow than valleys farther east.

Coral Creek, the only major tributary to the north of the Bow River drops fairly steeply from an upper subalpine basin through slopes covered with lodgepole pine forest, to the Bow.

There is an extensive burn extending from near Storm Mountain Bungalows over Vermilion Pass into B.C., which dates to 1968. The tree regeneration is predominantly lodgepole pine, and the trees are now from 2 to 4 meters tall and patchily distributed.

The most extensive alpine areas are the Bourgeau Meadows, Gibbon Pass, Consolation Pass and Sentinel Pass, but most of the land surface above the upper subalpine ecoregion is rock and glaciers.

Wildlife Use

Every species of ungulate occurring in Banff and Jasper is found in the Bow River watershed with the exception of Woodland caribou. Elk and moose winter along the Bow River and sheep range in summer throughout most of the watershed but winter primarily in adjacent areas. Goats occur on all the mountains. Mule deer winter in the Bow River valley and there is a resident population of white-tailed deer. There is a mineral lick used by goats at Gibbon Pass and other licks are reported at Copper Mountain, Mount Isabella and the head of the Lost Horse Creek valley. Flygare (1979) has determined that 30% of the ungulate roadkills on highway 1 occur in this drainage.

Bighorn sheep occur on Mounts Brett and Bourgeau, this population being isolated by the Bow River and Brewster Creek from the bulk of the bighorn sheep range in Banff. The Bourgeau herd is estimated at 120-130 (Jacobson 1981). They winter in the Healy Creek watershed. An aerial survey in November 1977 revealed 28 sheep on Mount Isabella and seven on Castle Mountain (Jacobson 1977). A small population of 20 to 30 sheep summers on Helena Ridge and Castle Mountain (Stelfox 1978) and winters on the latter mountain.

Elk range throughout the middle Bow River watershed in summer but are confined during most winters to the valley floor of the Bow River downstream from Moraine Creek. The meadows and aspen forests along the northeast sides of the valley are particularly important in winter.

Moose are uncommon in the middle Bow River watershed due to a combination of habitat loss to forest succession and mortality caused by trains and automobiles. The marshes and floodplain willow meadows between Muleshoe and Massive and near Eldon are wintering areas used by about 10 to 15 moose. Moose occur in the Vermilion Pass Burn, upper Coral Creek, and the valleys SE of the Bow River in summer, as well as along the Bow River floodplain.

Mule deer occur most commonly downstream from Johnston Creek on the Hillsdale slide and alluvial fans along the river and on the lower slopes of the Sawback Range in winter. White-tailed deer frequent the Bow River floodplain on a year round basis.

The middle Bow River watershed is only a tenth as important to Coyote as the adjacent lower Bow River watershed, no doubt due to greater snow accumulation and absence of garbage sources. Wolves formerly denned near Massive and two packs totalling 7 to 9 animals were reported in the area in the late 1940's, however there has not been a resident wolf population in the Bow River valley since the predator control campaigns of the 1950's. Cougars were formerly seen occasionally near Muleshoe and Hillsdale and a family was seen there on 9 November 1972 (Banff wardens card) but there have been none sighted since May 1975 when a female was killed on the highway at the mile 5 bridge.

Mustelids are fairly common in the middle Bow River watershed, with a small resident population of mink along the Bow River and an average of 1.9 American marten tracks /km-day in the subalpine side valleys.

The only known osprey nest sites in Banff are in the middle and lower Bow River valleys. Harlequin ducks rely on the middle Bow River as a major staging area in May and June before dispersing to nest throughout the park. A Western Bluebird was seen at the Silver City meadows.

A wide variety of small mammals has been recorded in this watershed, from yellow-pine and least chipmunks, bushy-tailed woodrats and various microtines to the rare pygmy and water shrews. Pygmy shrews were only recorded twice during the entire inventory, both times in the middle Bow River watershed in valley bottom white spruce/prickly rose/horsetail (C4) and lodgepole pine-spruce forests.

Beaver and muskrat occur along the Bow River floodplain and in a marsh area south of the river and about 1 km. west of the Sunshine turnoff.

Management

Much of the middle Bow River watershed, is important ungulate range, particularly the Hillsdale Meadows, the shrubby meadows along the Bow River valley bottom, Silver City Meadows, and most of the north-east side of the main valley. Development of these areas would involve major potential wildlife impacts.

The fires of the 1880-1900 period have resulted in extensive even-aged stands of unproductive lodgepole pine in the Bow valley. Controlled burning of parts of these forests would result in increased range for deer, elk and moose and may partly mitigate highway and railroad mortality of ungulates in this watershed. At present this mortality is a serious drain on elk and moose populations. Fencing, speed bumps and other methods of reducing animal/vehicle collisions would reverse the on-going decline of these ungulates.

The Lake Louise area is heavily developed for both summer and winter recreation. Jacobson and Loewen (1980) have discussed the effect of existing ski facilities at Mount Whitehorn on goats of the Slate Range. Ski area expansion may cause further adverse impacts.

UPPER BOW RIVER WATERSHED

This watershed lies entirely within the Main Ranges of Banff (Figure 1.1). It is roughly bisected by the Icefields Parkway and the only developments consists of a camp ground at Mosquito Creek, a guest lodge at Bow Lake, and a road and interpretive exhibit facility at Bow Summit. The southwest corner of the watershed includes parts of highway 1, highway 1A, CPR railroad, and a large gravel pit near the junction of highway 1 and the Icefields Parkway.

The upper Bow River watershed lies exclusively within the subalpine and alpine ecoregions. The valley is broader than most subalpine valleys, with extensive alluvial meadows and poorly-drained till deposits along the valley bottom. The entire western flank of the watershed is glaciated, with smaller cirque glaciers on Mt. Hector and Cirque Peak to the east.

Downstream from Hector Lake lodgepole pine and lodgepole pine-spruce forest predominate, with Engelmann spruce-subalpine fir forests at higher elevations on the valley slopes and upstream from Hector Lake.

There are extensive alpine areas at Dolomite Pass, north of Hector Lake and at the headwaters of Mosquito Creek. Bow Summit is one of only two places in Banff and Jasper where an all-weather road reaches timberline.

Wildlife Use

Every species of ungulate known to occur in Banff and Jasper except white-tailed deer and bighorn sheep has been recorded in the upper Bow River watershed, including a single record of a Woodland caribou in Dolomite Pass on 15 March 1979 (BNP warden card).

Elk are uncommon and do not winter in the upper Bow River valley. Moose are widespread and winter throughout the valley from near Bow Summit south. Mule deer do not winter in the valley and are scarce at other seasons. Snow depths are generally too great to allow most ungulates to remain in this drainage in winter.

Goats have been observed on the Waputik Range and the mountains east of the Bow River but their winter ranges are not known.

The absence of records of wolves and cougars and the low winter density of coyotes reflect the combination of deep snow accumulation and low ungulate densities. Mustelids - American marten, Short-tailed weasel and others - are fairly common and, as in the case of most subalpine valleys, Wolverines range through the watershed regularly.

Bow and Hector Lakes are part of a chain of large lakes running from northwest to southeast parallel to the continental devide. Although these lakes are not used by large numbers of migrant shorebirds and waterfowl, they are focal points for those species which do migrate through the central Rockies. Rarities are occasionally recorded here, including Banff and Jaspers only record of a Ruddy Turnstone. Regular migrants include Barrow's Goldeneye, White-winged Scoter and Surf Scoter.

Hawk Owls probably nest in the upper Bow River valley, and there is a Golden Eagle territory east of Bow Lake.

Management

The Bow meadows, below Bow Pass, are important moose winter range. Snowmobiling and cross-country skiing may cause stress to moose wintering in the Bow meadows. Snowmobiles push down and bury shrubby stems, which may reduce available forage for moose and ptarmigan. Expansion of existing tourist facilities or development of new ones may further encroach on this wintering area.

LOWER SPRAY RIVER WATERSHED

This watershed lies within the front ranges of Banff and is bounded on the east by Mount Rundle and the Goat Range and on the west by the Bourgeau and Sundance Range (Figure 1.1). The watershed is almost entirely subalpine with few alpine areas.

Forest fires burned most of the watershed from 90 to 50 years ago. In addition, parts of the watershed were, until the 1930's, under a logging lease to the Eau Claire Logging Company of Calgary and much timber was removed at that time.

The Spray River is controlled by a dam at the south end of the Spray Lakes Reservoir, built in the 1940's. Part of these earthwork dams collapsed in the late 1940's causing a large rush of water down the Spray and into the Bow River. In places, as much as 2.5 m of gravel was deposited. This can be seen at the junction of Goat Creek and the Spray River where a warden station was buried to the rooftop in gravel washed down by the flood.

Lodgepole pine and lodgepole pine-spruce forests dominate much of the watershed although in the valley-bottom between the Goat and Sundance Ranges there is extensive Engelmann spruce-subalpine fir open forest.

Developments in the watershed include a fire road that follows the Spray River to the park boundary, an abandoned road along Goat Creek, three warden cabins and a youth hostel.

Wildlife

Deer, elk, moose, goat and sheep are common in this watershed and the area is one of the principal winter elk ranges of Banff.

Mule deer frequent the lower Spray River valley in winter and warden records indicate that mule deer occur throughout the watershed during the snow-free season. There is only one record of white-tailed deer in the area, a doe seen near the Spray road in August 1955.

Elk are common in the watershed and the grassy slopes of the Goat Range are an important winter range. The watershed had the third highest winter tracking index for elk in Banff. During a 1977 January aerial survey 88 elk were counted in this watershed (Jacobson 1977).

Moose occur at low densities throughout this watershed. Most records are from the 1940's to mid-1960's (park wildlife cards), reflecting the general decline in moose numbers throughout Banff in the last two decades.

Goats range on all the mountains of this drainage, especially the slopes of Sulphur Mountain, Mount Rundle and the Goat Range. There is a dry mineral lick at Kilometre 12.8 of the Spray Fire Road. From one to nineteen goats have been observed there during summer months. Thirty goats were observed at the lick in August 1972 (warden reports).

Historically, the lower Spray watershed was not known for sheep (Green 1949) and wardens did not report any until the early 1950's; thirty two sheep were observed on Sulphur Mountain in June 1952 (Warden records). Sheep are most commonly observed at the lick and on the north end of the Goat Range throughout the summer. An aerial survey in November 1977 revealed 71 sheep in the watershed, 7 on Mount Fortune and 64 at the south end of the Spray valley (Jacobson 1977).

Winter track count transects showed low densities of coyote, marten and wolverine. There are three reports of wolves in the Spray watershed, all either near Eight Mile cabin or north of there, during the period 1946-1955; the only recent report is a wolf observed at Kilometre 24 of the Spray fine road in July 1974 (warden records).

In October 1973 a racoon was observed at the "south end of the Spray Lakes" (warden record), possibly out of the park and definitely well out of the known range of this species.

Black and grizzly bears are both present, with most records of black bears being at the downstream end of the valley, while grizzlies occur sparsely throughout the watershed (warden records).

There were several reports of cougar between 1947 and 1973. Cougars were commonest in the Spray "8 mile" area (warden records). There are no recent records.

Management

Both the Spray Reservoir and the Spray Fire Road impact this watershed. The unnatural flow regime of the Spray River caused by artificial control at the Spray Reservoir decreases invertebrate numbers, thus reducing the value of the river to such species as harlequin ducks and dippers. Major fluctuations in water flow should be prevented.

Increased recreational use of this area as a consequence of recreational development of adjoining provincial lands may lead to more frequent bear problems and disturbance of wildlife unless regional, cooperative zoning and management plans are developed.

Very little is known about the sheep and goat population of this watershed, and the effect on park populations of hunting on adjoining provincial lands.

UPPER SPRAY RIVER WATERSHED

This watershed lies entirely within the Main Ranges of Banff and includes several lakes of which Marvel Lake, in the Bryant Creek valley, is the largest (Figure 1.1). The bulk of the area is subalpine with some alpine areas at Wonder Pass, Og Pass, Assiniboine Pass and

Palliser Pass. Fires burned most of the valley-bottom areas about 90 years ago, and there is a more recent burn along upper Bryant Creek. Vegetation is diverse with a wide range of forest types, from Engelmann spruce-subalpine fir open and larch-fir forests, to lodgepole pine-spruce and Engelmann spruce-subalpine fir closed forests. Lower subalpine shrub meadows occur in the vicinity of Bryant Creek Cabin and along portions of the Spray River.

The Bryant Creek area is popular as a route into Assiniboine and is used by both hikers and outfitters. The section of the Bryant Creek trail from the park boundary to above the Bryant Warden Cabin is wide enough that outfitters use wagons on it. In addition to the Bryant Warden Cabin, there is also a warden cabin in the upper Spray valley and a Parks Canada Trail Centre at the start of the Bryant Creek trail. A rough, good-weather road allows vehicular access to the park boundary. New developments of the Spray Reservoir, by Calgary Power, will apparently limit this access, while recreation development of the Spray Lakes area by the Alberta provincial government will increase recreational demand.

Wildlife

All ungulates found in Banff, except Woodland caribou, have been recorded in this watershed. Of these, Mule deer, moose, elk and goat are the most common. In the 1950's white-tailed deer were observed at Wonder Pass, the head of Bryant Creek and near the Bryant Cabin where a male and female and 2 young were seen in July 1955. There are no recent records for the area.

Mule deer occur throughout the watershed in summer, but most migrate elsewhere in winter.

No moose have been recorded in the Bryant valley, however moose have been observed in lower subalpine shrub meadows in the Spray valley during July. Warden records for moose, throughout the watershed, are common between 1946 and the early 1960's, after which reports decline. Winter track count transects revealed moose tracks along Owl Creek in March.

The upper Spray River watershed is important summer range for elk, with the areas of highest importance being the Allenby Creek area, upper Bryant Creek and Palliser Pass. Elk do not usually winter in this watershed, probably migrating to the lower Spray and Kananaskis areas.

Goats occur throughout the watershed and small herds are most often seen on the slopes of Wonder Peak and Cone Mountain. Sheep are rare in this watershed with very few records, mostly during summer along Bryant Creek valley.

All carnivores occurring in Banff and Jasper have been recorded in this watershed. Cougar tracks were reported in the Bryant Creek valley in March 1948 and in the Palliser trail area in November 1943 and February 1969. Two wolves were observed at the mouth of Bryant Creek in October 1953 and another at Whiteman Pass in January 1958. There are no recent reports of either of these species.

No coyotes were seen in the watershed during the inventory but warden records indicate that coyotes are regularly present in summer.

No black bears were observed in the area during the inventory. There are a few reports of black bears in the Bryant area in the late 1950's (warden records). Grizzly bears are fairly common and diggings were observed in various habitats in both the Bryant and Spray drainage in June and July. Warden records show that grizzly bears are most often seen in the Bryant Creek Flats area, Wonder and Assiniboine Passes, and on slopes above the Marvel Lake Trail.

The Spray River valley had the second highest density of marten tracks recorded in Banff, while use of the Bryant Creek area by marten was minimal. Tracks of a fisher were recorded near the Bryant Warden Cabin in January, 1978, and further winter surveys found tracks of a fisher in Engelmann spruce-subalpine fir forest along the Spray River during the same winter.

Golden eagles nest in this watershed.

Management

Heavy recreational use of this watershed may lead to conflicts with grizzly bears, which are widespread. Recreational pressure can be expected to increase with development of recreational facilities on adjoining Alberta provincial lands, and with increased access from B.C. made possible by logging roads.

Winter ranges of elk that summer in the upper Spray watershed are not known and the extent to which these elk are affected by hunting and development outside the park can consequently not be assessed.

BREWSTER CREEK WATERSHED

This watershed is bounded on the east by the Bourgeau Range and on the west by the mountains along the continental divide (Figure 1.1). It lies mostly within the Main Ranges of Banff.

The watershed not only contains small narrow subalpine valleys such as that of Howard Douglas Creek but also encompasses extensive alpine areas such as the Sunshine Meadows, extending from Citadel to Healy Pass along the continental divide.

Much of this watershed was burned in 1880 (C. White, Banff Warden Service, pers. comm.). Lodgepole pine and lodgepole pine-spruce forests occupy much of the Brewster valley and parts of lower Healy Creek. Engelmann spruce-subalpine fir forests occur at the upper reaches of the drainage and extensive open subalpine larch/heath forest forests are found at Healy Pass and bordering the Sunshine Meadows.

The Sunshine Meadows area is the site of a major ski development, Sunshine Village, and an all-weather public access road follows Healy Creek to that creek's junction with Sunshine Creek where the road terminates at a large parking lot. A restricted-access summer-use road continues up Sunshine Creek to Sunshine Village. The watershed receives heavy recreational use, particularly in the area of the ski resort. In the summer, and to a lesser extent in the winter, the Sunshine area is the main starting-off place for hikes going into Mt. Assiniboine Provincial Park, B.C. Many hikers also travel up Healy Creek and over Healy Pass to the Egypt Lake area.

The Brewster valley is used extensively by outfitters guiding tours into Assiniboine. Two private outfitters' cabins are located in the valley, one at Ten Mile and the other just below Allenby Pass.

Wildlife

Moose, elk, sheep, goat and mule deer occur regularly in the Brewster watershed. The area is highly important to moose and sheep. The Brewster valley, from winter track count transects, has the second highest density of moose in Banff and Jasper, and its importance to wintering moose is further indicated by an aerial survey which revealed ten moose in the valley in January 1978 (Everts pers. comm.).

Mount Bourgeau is one of the western-most sheep winter ranges in Banff, with winter use concentrated on the slopes above the north side of the Sunshine Village ski road. The 1978 aerial survey (Ibid) found 38 sheep on this range. Sheep also winter at

Fatigue Pass. At least two mineral licks are used by sheep in the Healy Creek valley.

Warden Perry Jacobson (1981) estimates that 120-130 sheep comprise the Bourgeau population. Eighty four were counted in the area during a September 1981 aerial survey.

This watershed sustains low densities of mountain goats along the north side of the Howard Douglas valley (Perry Jacobson pers comm.) Goats have also been seen at Simpson Pass, Fatigue Pass, and the upper Brewster valley.

Winter track-count transects show low winter use of the Brewster valley by elk, however none were seen during winter aerial surveys by the Warden Service and Canadian Wildlife Service in this watershed.

Both black and grizzly bears occur in the Brewster Creek watershed. Grizzly bears have been seen in most areas of the drainage whereas most black bear sightings are in the Healy Creek area. Wolverine densities, based on winter track count transects, are the third highest of any watershed in Banff.

The Allenby Pass area is one of the few places in BNP known for badgers. Cowan (1943) refers to badgers at Allenby Pass and one was seen at Allenby Pass in the summer of 1977. During the winter of 1979-1980 there were several reports of lynx in the Brewster valley (Sue Davies pers. comm), at a time when lynx were uncommon in Banff and Jasper.

Management

Due to the Sunshine valley ski area and to proximity to Mount Assiniboine and the Egypt Lake area, this watershed receives heavy recreational use. During the winter of 1979-80 the ski area constructed a gondola lift system to replace the Sunshine Creek road as the means of transporting the public to the ski area. This lift is to be in year-round operation, thus placing the Sunshine Meadows within the reach of thousands of daily summer visitors. This increased use may lead both to adverse impact on habitat and to increased disturbance of wildlife, particularly bears.

Warden Perry Jacobson (1981) has identified several management concerns regarding sheep in the area. These include mortality from artificially-released avalanches on the slopes of Mount Bourgeau, disturbance and habitat loss due to development of the Goats Eye area, and vitality problems related to the lungworm load of the population. This sheep population is unique in that it ranges wholly within the Main Ranges under habitat conditions that are marginal for sheep survival. Habitat loss and disturbance should be minimized, and the extent to which sheep hunting in Mt. Assiniboine Provincial Parks affects this population should be assessed.

Stephen Herrero (U of C, pers. comm.)reports that severe over-hunting of grizzly bears in the upper Simpson River valley in the 1950's and 1960's led to their near-elimination from the Sunshine Meadows area. Park wildlife populations that move outside the park will be subjected to increasing hunting pressure and disturbance as access to remote areas increases. Cooperative planning and management of these populations with provincial agencies may be essential to their continued survival and integrity.

FORTYMILE CREEK WATERSHED

This area of narrow valleys with steep avalanched slopes lies within the Front Ranges of Banff (Figure 1.1). It contains little alpine terrain and the predominant vegetation is Engelmann spruce-subalpine fir except for an lodgepole pine-dominated burn along upper Elk Creek. Alluvial shrub meadows are limited to the Elk Creek valley and small areas along upper Fortymile Creek. There are extensive open subalpine larch/heath forest

forests at Fortymile and Elk Passes.

There is a small water impoundment and dam on Forty mile Creek two kilometres above highway 1. The only other development is a warden cabin near Mystic Lake. The area is used by hikers and backpackers in summer and cross-country skiers in winter.

Wildlife

Fortymile Creek watershed is used by deer, elk, moose, goat and sheep to limited extents. Fortymile and Elk Passes are important elk rutting ranges. Track count transects indicate low winter use of the area by deer, elk and moose.

Coyotes use the watershed to a limited extent in winter. Grizzly bears occur throughout the Fortymile Creek watershed; black bears are uncommon, being more or less confined to the lower parts of the watershed.

Management

In order to ensure that parasites (*Giardia lambia*) do not contaminate the Banff townsite water supply, beavers have been trapped and destroyed along Fortymile Creek. The loss of beaver and their dams removes an important prey species and a source of valuable wetland habitats and is a short-term measure at best, as beavers will continue to invade this watershed from the Bow valley. Effective filtration of this water or the development of an alternative water supply would eliminate the need to kill beavers.

JOHNSTON CREEK WATERSHED

This watershed lies partly in both the Front and Main Ranges (Figure 1.1). It is a narrow valley, bounded on the north-east by the steep slopes of the Sawback Range and on the south-west by cliffs and steep slopes of Helena Ridge and Pulsatilla Mountain. The valley is predominantly subalpine with some alpine meadows in the vicinity of Pulsatilla and Badger Pass. Forests of Engelmann spruce-subalpine fir are found in the upper part of the valley while the lower two-thirds of Johnston Creek valley were burned during the years 1889-1891 (C. White, Banff warden service, pers. comm.) and supports successional lodgepole pine and lodgepole pine-spruce forest. Along Johnston Creek there are extensive upper subalpine shrub meadows.

A popular feature for park visitors is Johnston Canyon at the southern end of the valley; other than hiking trails and a warden cabin, the only developments in this watershed are a campground, bungalow resort, restaurant, service station and parking lot at the mouth of the canyon. A heavily-used scenic trail in the canyon consists of a concrete walkway supported by steel beams driven into the canyon walls.

Wildlife

Deer, elk, sheep and goat all occur in this watershed, and track-count transects indicate that the area has the third highest winter use by moose of Banff watersheds. Moose tracks were observed only downstream from Luellen Lake.

Elk summer throughout the watershed and winter at least as far upstream as the Ink Pots. Mule deer are not known to winter above the canyon. There is a mineral lick used by elk near a small lake on Pulsatilla Mountain.

Goats occur sparsely throughout the watershed at all seasons. Pulsatilla Pass is a major ram summer range which is also used by nursery groups. Twelve rams were reported at Pulsatilla Pass in August 1955 and 15 in August 1975 (Warden records). Mixed herds summer on Mt. Ishbell, on Hillsdale Summit and in the Johnston Canyon area. Sheep winter on Mount Ishbell and along the southern end of the Sawback Range.

Grizzly bears occur throughout this watershed and diggings are common in the upper subalpine shrub meadows along upper Johnston Creek.

Although other mustelids were present in only low or moderate densities, winter track count transects revealed a higher density of wolverine tracks here than in any other watershed in Banff and Jasper. Fisher tracks were recorded once.

Specimens of the uncommon Richarson's water vole were collected in upper subalpine shrub meadows along Johnston Creek together with a specimen of the rare Water shrew.

Johnston Canyon is one of only two, or possibly three, known black swift nesting areas in Alberta. In July 1978 there were six nests in use in the canyon.

Management

Johnston Canyon is the only Banff nesting area of the black swift. Further development in the canyon should be carefully assessed to minimize its impact on this rare species.

BAKER CREEK WATERSHED

This watershed lies in the main ranges of Banff and includes several large alpine lakes (Figure 1.1). Baker Creek flows through a narrow subalpine valley, bounded on the east by Protection Mountain, Mount Avens and Tilted Mountain and on the west by the mountains of the Slate Range. The lower end of the valley was burned 90 or more years ago and is covered by lodgepole pine-spruce forest, while further up the valley Engelmann spruce-subalpine fir forests predominate. The extensive alpine area contains a mosaic of vegetation, from heath meadows and water sedge-beaked sedge (H11)s to alpine grassland areas.

Other than hiking trails and a cabin in the lower Baker Creek valley used by boy scouts, there are no developments in the area.

Wildlife

Deer, elk, moose, and sheep occur in this watershed in generally low densities. The mountains of the Slate Range are a major goat range. Elk and moose tracks were recorded at low densities along the Baker Creek valley during winter track count transects. A November 1976 aerial survey by the Warden Service located two moose in Baker Creek valley and 48 elk: 30 along Wildflower Creek, 9 in the Baker Creek valley and 9 on Mt. Lipalian (Jacobson 1977), indicating some of the watershed is early winter range.

A major year-round goat range incorporates Redoubt, Lipalian and Anthorzoan Mountains, Heather Ridge and Brachiopod Mountain. The maximum population count in recent years is 35 (Jacobson & Loewen 1980). Warden records indicate that this population was higher in the past, with at least 42 goats present until 1969. This population decline is also reflected in a drop in the average herd size from 10.1 during the period 1958-1960 to 5.9 for the period 1970-1978.

Sheep are scarce and probably occur in this watershed only during the snow-free months. The first record of sheep was in August 1958 when 4 rams were reported on the north-east slopes of Brachiopod Mountain. No sheep were seen during this inventory. There are records of 23 sheep south of Boulder Lake in September 1971 and 11 sheep about 9.6 km. up Baker Creek in May 1975. An aerial survey in November 1978 revealed 13 sheep in the Baker Creek area (warden records).

Black bears have not been recorded in this watershed. Grizzlies occur throughout the area in low densities. This watershed has the second highest concentration of

wolverine tracks in Banff and the third highest in Banff and Jasper. The majority of tracks were in the upper Baker Creek valley in shrub-dominated burn areas.

A Red fox was seen in lower Baker valley at a lick in October 1972 (Warden files).

Management

Declining goat numbers on the Slate Range have been related to disturbance and habitat loss caused by downhill ski developments on Mount Whitehorn (Jacobson and Loewen 1980). The extensive alpine and subalpine complex of meadows and lakes at the northern end of this watershed is a unique habitat deserving of special protection.

PIPESTONE RIVER WATERSHED

This watershed lies mainly within the main ranges of Banff. (Figure 1.1) The lower Pipestone River flows through a fairly wide valley. Most of the watershed is subalpine, but there are extensive alpine areas in the Molar Pass and Pipestone Pass areas. There is a variety of vegetation in this watershed, partly due to the widespread fires of 100 to 90 years ago. Much of the broad lower Pipestone River valley is lodgepole pine-spruce forest as a result of a major fire in 1880 (C. White, Banff Warden service, unpublished data).

Along Little Pipestone Creek and the Pipestone River, stands of lodgepole pine-spruce and Engelmann spruce-subalpine fir forest occur as well as Engelmann spruce-subalpine fir open forest and lodgepole pine-dominated burn and shrub-dominated burn areas. Upper subalpine shrub meadows are found in parts of the Skoki valley and in the Singing Meadows. Engelmann spruce-subalpine fir forests are more common further up the Pipestone River valley. Subalpine larch-subalpine fir/grouseberry-everlasting (C23) forest is present in several locations.

Other than hiking trails, two warden cabins in the Pipestone River valley and the Skoki Lodge, there are no developments in most of this watershed. The lower Pipestone valley includes parts of the Lake Louise Ski area and associated facilities on Mount Whitehorn.

Wildlife

Deer, elk, moose, goat and sheep occur in the watershed. For deer, elk and sheep the watershed is primarily summer range and no tracks were recorded during winter surveys. No deer were seen but pellets were found in a variety of subalpine habitats.

Elk are commonest in the Fish Lakes area, Pipestone and Molar Pass, Singing Meadows, and other upper subalpine shrub meadows along the Pipestone River, Molar Creek and Little Pipestone Creek.

Moose occur throughout the watershed at all seasons, with winter use concentrated in the valley bottoms. There are many warden records of moose throughout the watershed during both summer and winter.

Goats occur throughout the watershed, particularly on Cataract, Cyclone and Whitehorn Mountains, Merlin Castle and Mount Skoki. In June as many as 26 goats have been observed on the slopes of Cataract mountain in the upper Pipestone River valley, 11 on the east slopes of Merlin Castle in August and 4 on Cyclone Mountain (warden records). The ski development on the Whitehorn section of the Slate Range has caused a decline in one of these goat populations (Jacobson & Loewen 1980).

Sheep are rare in the watershed. Seven were observed on slopes of Cataract Peak above the Singing Meadows and six ewes with two young of the year were reported near Pipestone Pass Cabin in September 1974 (warden records).

Coyotes are scarce at all seasons and there is only one recent record of a fox track. Wolves occurred in this watershed until the 1950's and may be re-establishing a population in the area. In September 1972 a wolf that was attacking an elf calf 17.6 km up the Pipestone River was frightened off by a helicopter. In September 1975 a wolf and three pups were observed at the junction of the Fish Lakes - Pipestone trail.

Moderate densities of mustelid tracks were recorded on track count transects. There is one recent cougar record; one was seen in June 1978 on the Slate Range near Little Pipestone cabin.

Management

The relatively undeveloped nature of this watershed and its remoteness render it free of major management concerns related to wildlife at present. In the vicinity of Mount Whitehorn, goat populations have been shown to have declined subsequent to ski resort development (Jacobson and Loewen 1980).

CASCADE RIVER WATERSHED

This large, complex watershed lies wholly within the Front Ranges of Banff (Figure 1.1>.

The upper Cascade (upstream from Cuthead Creek) includes Flint's Park, a broad valley which, along with much of the valley of Sawback Creek, was extensively burned in the 1930's. It is the western-most part of the watershed and receives the highest winter snow accumulation.

The middle Cascade (between, and including the drainages of, Cuthead and Stoney Creeks) was burned in the 1900's and is covered with lodgepole pine forest, extensive steep, grassy mountain slopes, and shrubby alluvial wetlands. It is undeveloped except for a limited-access fire road, a warden cabin and an abandoned elk trap corral.

The lower Cascade (downstream from Stoney Creek) has a similar fire history to the middle Cascade and is by far the most heavily developed part of the watershed. Between Stoney Creek and the Bow River there are a scenic loop road, a hydro-power development including two large reservoirs (Lake Minnewanka and Two-Jack Lake), a landfill site and gravel quarry, a campground and several day-use facilities, and an abandoned coal mine and town at Bankhead. The Cascade river has been diverted by the power development and its former bed remains dry during most of the year.

Lodgepole pine forest predominates in most of the Cascade River watershed, with some small stands of Douglas fir/hairy wild rye (C1) forest in the montane portion of the watershed. Engelmann spruce-subalpine fir forest is generally confined to the higher slopes and side valleys that escaped the fires of the early twentieth century. West and south-facing slopes are dry and covered with open coniferous forest or grassland. There are few alpine areas.

Wildlife

This watershed is one of the most important in Banff for sheep, elk and mule deer. All ungulates that occur in Banff are found here except caribou. At least three mineral licks, used by sheep, elk and goats, are known in this watershed.
White-tailed deer have never been recorded in the upper part of the Cascade watershed and only rarely elsewhere. Mule deer occur throughout the watershed in summer and winter along the Palliser Range in low densities and in the lodgepole pine and Douglas-fir forests of the lower Cascade.

Elk winter along the Palliser Range, on Grassy Mountain and the slopes around the head of Cuthead Creek, and along the valley bottom as far upstream as Cuthead Creek. During late winter most nursery groups of elk leave the middle part of the watershed and only small bands of bulls remain upstream from the fire road bridge. Moose winter in all parts of the watershed, mostly at low elevations.

Goats occur at low densities. Most records are from the Sawback Lake area, the Cascade Range and the Palliser Range east to Dormer Pass. Goats have not been recorded on Mount Inglismaldie since July 1948 and are rare east of Lake Minnewanka (Banff warden records).

During summer sheep occur throughout the Cascade watershed but in winter they are generally confined to traditional winter ranges in the middle and lower Cascade. the Palliser Range, Cascade Range and Grassy Mountain are important rutting ranges which also sustain wintering sheep herds. There are small patches of winter range on grassy slopes around the head of Cuthead and Stoney Creeks. Sheep have been intensively studied in this watershed, notably by Stelfox (1978) and Geist (1971, etc.).

Coyotes den in the upper Cascade and frequent the entire watershed in summer but are confined mainly to the area downstream from Cuthead Creek in winter. Wolves range throughout the watershed but have not denned there in recent years, the nearest known den being in the Panther River valley. Most of the wolves that use this watershed also wander outside the park.

The Cascade watershed is noted for its high density of grizzly bears, which have been studied by Hamer et al. (1980). Black bears are rare upstream from Lake Minnewanka. In the past a sanitary landfill in the lower Cascade served as a major attractant to both species. The landfill was closed in 1981.

Marten, wolverine and weasels are less common in the lower Cascade than they are farther upstream. Badgers occur along Cuthead Creek.

The northern pocket gopher may occur in the Ghost Lakes area; it occurs nowhere else in Banff and Jasper. Beavers occur along the Cascade River and Cuthead Creek.

Management

The montane portion of the Cascade watershed has been extensively disturbed. The importance of this area to wintering ungulates and to other wildlife render further incremental development of this area undesirable.

The accessibility to and use of the Ghost Lakes area by trail bikes and all-terrain vehicles may lead to problems with poaching of ungulates and grizzly bears.

Sheep, elk, bears and, especially, wolves which use the Cascade watershed frequently range outside the park and become susceptible to hunters and provincial problem wildlife control staff. Six wolves poisoned by provincial staff in the Waiparous drainage in 1976 were probably park wolves. Monitoring of these vulnerable populations is important to assess the impact of hunting and control killings. Cooperative agreements to restrict access near park boundaries would reduce the impact of hunting.

The Cascade watershed is unique in that it sustains large, healthy populations of ungulates, grizzlies, wolves and other wilderness wildlife in close proximity to Banff townsite and the most heavily- developed part of the park. Protection of its integrity and isolation will ensure that this valuable area will continue to sustain its diverse and interesting fauna.

RED DEER RIVER WATERSHED

This watershed lies entirely within the front ranges of Banff National Park (Figure 1.1). It is a large and complex drainage and, in addition to the Red Deer River, includes the Panther and Dormer River valleys. Red Deer Lakes, Douglas Lake and Horseshoe Lake in the upper Red Deer area are the principal lakes of the area. The watershed is mostly subalpine but there are some notable alpine areas, including Snow Creek Summit, Divide Creek Summit, portions of McConnell Creek and Douglas Lake valleys and parts of the Sandhills Creek valley northwest of the Sandhills Warden Cabin, a valley that includes several alpine lakes. The Bonnet Glacier is the source of Douglas Creek.

The Cascade Fire Road transects the upper Panther River valley over Snow Creek Summit into the lower Red Deer valley at Scotch Camp, and out of the park to the government-owned Ya-ha-Tinda Ranch. This same road allows public access by vehicle to the park boundary. Other than six warden cabins - two on the Panther, one on the Dormer and three on the Red Deer - the fire road is the only development in the area. An old bulldozer track, possibly related to construction of the Barrier Warden Cabin, is visible in some areas between Windy and the park boundary.

Portions of both the Panther and Red Deer valleys have been burned in the past and as a result lodgepole pine and lodgepole pine-spruce forests predominate. Much of the upper Red Deer valley and the higher areas of the Panther and Dormer are covered by Engelmann spruce-subalpine fir. Lower subalpine shrub meadows and upper subalpine shrub meadows line most major streams, particularly along sections of the Dormer and Panther and in the vicinity of Scotch Camp.

Ungulates

This watershed is highly important to deer, moose, elk, goat and sheep. All ungulates found in Banff, except Woodland caribou, have been recorded here. The watershed is important winter elk range. Moose, sheep and goat also winter in the watershed. Ten mineral licks are known from the watershed, two in the Dormer drainage, three in the Panther drainage, and five in the upper Red Deer drainage. These are used by moose, elk, sheep and goats.

Moose are present at low densities throughout the Panther-Dormer area during all seasons. Warden records indicate that moose were more abundant in this area in the 1940's and 1950's. In the lower Red Deer valley, east of Mt. Prow and Mt. McConnell, moose are moderately abundant. Winter track count transects showed moderate use of the area.

In general, the upper Red Deer watershed is of lower importance to ungulates. Moose, from winter track counts, were the only ungulate present in winter. Higher snowfall than in the more easterly portions of this watershed limits use by other species. An aerial survey in November 1976 revealed five moose: three along Oyster Creek and two in the Red Deer Lakes area.

Elk winter in much of the Panther, Dormer and lower Red Deer area, including the Sulphur Springs area, the Panther-Red Deer shortcut, sections of the Dormer valley and Dormer-Panther shortcut and the area between Harrison Lake and the Panther valley. A November 1976 aerial survey revealed 12 elk at Tyrell Creek, 10 at Divide Creek, 38 at Snow Creek Summit and 24 scattered throughout the Panther-Dormer area (Jacobson 1977). More elk antlers, 50, were observed in one subalpine meadow on the Panther-Red Deer shortcut than in any other area in Banff and Jasper.

In the Panther drainage elk are common throughout the upper subalpine and alpine ecoregions in summer, as well as frequenting the river flats. Other important summer elk

ranges include the lower Red Deer valley and the Snow Creek and Divide Summits.

There have been very few records of white-tailed deer. Most records were in summer. Mule deer occur throughout the Red Deer watershed from June to October. Winter track count transects showed low winter use of the Panther drainage by deer whereas the lower Red Deer had the second highest track density recorded in Banff.

Sheep occur in all parts of the Red Deer River watershed in summer but are rare west of the upper Red Deer. Important winter ranges include the Bare Range above the Panther River, Dormer Summit and North Falls Creek, Mount White, the northern Bare Range, and the slopes above Tyrrell and Divide Creeks.

Goats are similarly widespread but are considerably less abundant. Major goat ranges includes the Bare Range, where a count of 63 goats in October 1946 (warden records) indicates that the population has declined significantly (no more than 11 were observed there during this inventory). Other goat ranges include Mount White, the upper reaches of McConnell and Divide Creeks, the slopes above Sandhills Creek, and Mount Douglas.

Wolves frequent the entire Red Deer watershed, particularly the lower parts the major river valleys. Wolves have historically denned in one part of the Panther River valley (warden records) and a sighting of five adults and two pups in the summer of 1979 indicates that the area is still in use. There is also a recent den record (July 1974) in the lower Red Deer valley. The highest recent count of wolves was a pack of eleven at Scotch Camp in July 1974 and on Snow Creek Summit in October 1974 (park wildlife cards).

Black bears are scarce, although problem bears from the developed parts of Banff are commonly relocated here. Grizzly bears are relatively common and occur throughout the watershed. All species of mustelids that occur in Banff are present in this watershed in low to moderate numbers. Badgers den along the Red Deer River near Scotch Camp and have been observed along Wigmore Creek (warden records).

Beavers are present along the major valleys and active lodges have been recorded as high as Wigmore Lake and Snow Creek Summit. Muskrats occur at Wigmore Lake and in the Sandhills Cabin marsh.

A number of uncommon bird species have been recorded in this watershed including Pectoral and Least Sandpipers and Short-billed Dowitcher (Wigmore Lake), White-throated Sparrow (Scotch Camp) and Golden-crowned Sparrow (Snow Creek Summit). The Scotch Camp and Tyrrell Flats grasslands are unique habitats which attract unusual grassland species and early migrants.

Management

The Red Deer watershed is an ecologically diverse area which sustains virtually all the major wildlife species which occurred here in pristine times, except bison. Several ungulate species occur in large numbers and sustain a healthy wolf population. The size and remoteness of the area ensures that grizzlies can exist in healthy numbers with minimal disturbance by humans. The preservation of this watershed's remoteness will ensure that this valuable area and its wildlife will continue intact.

Wolves in this watershed range outside the park, particularly in winter, and are exposed to poisoning by provincial agencies. Monitoring and cooperative management of wolves and other wildlife which are hunted on provincial lands are essential.

The Cascade fire road through Ya-ha-Tinda Ranch, and mineral exploration roads on provincial land, provide increasingly ready access to the park boundaries in the Red Deer watershed. Poaching, legal hunting and increased disturbance of wildlife will inevitably accompany new access if a limited-access buffer ecoregion is not maintained along the

park boundary.

CLEARWATER RIVER WATERSHED

This watershed lies primarily within the Front Ranges of Banff. The area is mostly subalpine but some extensive alpine ecosites exist in the Clearwater Pass-Devon Lakes area and the upper reaches of Roaring and Martin Creeks.

Engelmann spruce-subalpine fir forests predominate over most of the watershed, with lodgepole pine and lodgepole pine-spruce forests confined mainly to the lower Clearwater. There has been no development of the area other than a closed cart track in the lower valley from provincial lands outside the park, and the Indianhead Warden Cabin.

Wildlife

Moose, elk, mule deer, sheep and goats are found in this watershed. Moose winter in the Clearwater and Martin Lakes area. A mineral lick on Indianhead Creek near the Clearwater River is used by moose.

Elk range throughout most of the clearwater in summer at all elevations. Some areas of the watershed, -Malloch Flats, the vicinity of Clearwater, Trident and Martin Lakes, and Indianhead Creek- are used as winter range.

Mule deer occur throughout the lower and upper subalpine parts of the watershed in summer. Winter track density of deer in this watershed was the third highest recorded in Banff and all tracks were in forested lower subalpine ecosites. In June 1978 a white-tailed deer was observed in a Engelmann spruce-subalpine fir forest in the upper Clearwater. The only other record of white-tailed deer in the watershed is a warden report of five, location unspecified, in December 1957.

The Clearwater watershed is an important sheep area and major ranges include the Indianhead, Malloch and Martin Creek areas, Mount Peters, and Divide Creek Summit. Up to 45 rams were seen in early June 1978 above the lower sections of Indianhead Creek. An aerial survey in November 1976 revealed 48 sheep - 28 in the Martin Creek area, 15 along Malloch Creek and 4 along Indianhead Creek (Jacobson 1977). In January 1979 six rams were observed on slopes above Indianhead Creek and sixteen unclassified sheep were seen on upper subalpine meadows on Mount Peters. Goats occur on Condor Peak, Mount Peters, Indian Lookout, Mount Malloch, Mount Harris and Mount Willingdon.

Coyotes occur in this watershed year-round. Warden records refer to "12 coyotes in the Clearwater District" in December 1957. Wolf tracks were observed along Malloch Creek in June and along Trident Lake in March. Warden records report from one to nine wolves in the valley from the 1950's to the 1970's. In the winter of 1971 9 wolves were reported to have killed 3 moose on the Malloch Falts. The watershed evidently supports a stable wolf population, though no dens have been found.

Grizzly tracks, scats and diggings were common in the watershed in June and August, 1978. In June a grizzly sow with a cub was seen near the Clearwater Cabin. Black bear records are uncommon and are mostly from lower subalpine parts of the watershed.

Winter track counts showed the Clearwater to have the second highest density of marten tracks in Banff. Only the upper Bow watershed showed higher use by martens. In summer, marten scats were common in lower subalpine lodgepole pine-spruce forests in the vicinity of Indianhead Warden Cabin. Short-tailed and least weasels and wolverine are present in low to moderate numbers along the valley bottoms. A meadowlark was observed in a lower subalpine shrub meadow by Clearwater Lake; alluvial grasslands along the lower Clearwater may be important habitats for grassland species which occasionally range into the mountains.

Management

As with other watersheds adjoining provincial lands, there is a potential problem with wildlife populations that range outside the park and are exposed to hunting or to conflicts with domestic animals. Bighorn sheep along Indianhead Creek and Peters Creek sustain losses to hunters and, occasionally, poachers; monitoring and cooperative management of these sheep are essential. Domestic livestock are grazed in the Clearwater Forest and are susceptible to predation by park wolves that range outside the park. The resultant control poisoning by provincial authorities could decimate the park wolf population and should be monitored.

The Clearwater watershed is a remote, ecologically diverse area which sustains intact populations of a variety of large ungulates and their predators. The Clearwater, with the Red Deer and Cascade watersheds, is exceptionally valuable in that it provides winter ungulate range and isolation from disturbance that are growing increasingly scarce in the montane parts of the park. A limited access ecoregion adjoining the park boundary, and continued protection of the area's pristine character, will ensure the on-going welfare of the area's fauna.

SIFFLEUR RIVER WATERSHED

The Siffleur River and Dolomite Creek valleys lie mostly within the main ranges of Banff (Figure 1.1). Much of the Siffleur River valley was burned in 1910 (C. White, Banff Warden Service, pers. comm.) and there has been little forest regeneration since then. Shrubby vegetation and open spruce-fir forest dominate the burned area. Engelmann spruce-subalpine fir closed forests are found on the unburned parts of the Siffleur and most of the Dolomite drainage.

Other than a warden cabin at Isabella Lake and an abandoned cabin in the upper Siffleur valley, there are no developments in the drainage. Access to the area is via hiking trails over Dolomite or Pipestone Pass or a trail that follows the Siffleur River from the park bundary.

Wildlife

Caribou, deer, moose, elk, goat and sheep occur in this watershed. This is one of the few areas of the park in which caribou occur regularly. Earliest records are from Simpson who reported tracks here in 1902 (Jacobson 1979). Aerial surveys have counted from 9-11 animals in this drainage. The Siffleur is the only watershed in Banff where caribou tracks were found during winter track count transects. The Siffleur showed the third highest track density of the six watersheds in Banff and Jasper in which caribou tracks have been observed in winter. In December 1979 tracks of an estimated eight to ten Woodland caribou were seen along Dolomite Creek north of Isabella Lake in Engelmann spruce-subalpine fir forest, however tracks were rare on the burned Siffleur side. In March 1980, with deeper snow (50-60cm vs 30cm in December), tracks of two or three caribou were observed near the park boundary, but none further up the valley.

The Siffleur is important moose range and has the highest winter track density for moose in Banff and the second highest in Banff and Jasper. In December and March moose were observed in the bottom of the Siffleur valley but none were observed in the Dolomite valley. Cowan (1943) estimated that there were 11 moose per square mile in the area during the early 1940's. Aerial surveys showed six moose in the Siffleur valley in the autumn of 1976 (Jacobson 1977).

There are two mineral licks in this drainage, both used by elk. One is just downstream from Isabella Lake and the other is on the east side of the upper Siffleur valley. In summer elk range over Pipestone Pass from both the Clearwater and Pipestone valleys. Elk are most common along the upper east side of the Siffleur valley and in Pipestone Pass. No elk winter in this watershed.

Deer and sheep are rare in this drainage. Tracks of one Mule deer were seen in the middle part of the Siffleur valley in December. No sheep have been recorded in this area though pellet counts indicate some occur on Conical Peak and Mount Kentigern and the alpine areas of the upper Siffleur - Pipestone Pass area. The west-facing slopes of Mt. Kentigern are goat range; eight were observed there in June 1978.

Coyotes are present in the Siffleur watershed in summer but no tracks were observed in winter. Grizzlies are present at low densities throughout the watershed. In December 1979 tracks of a fisher were seen in the Dolomite Creek valley in a lower subalpine lodgepole pine forest.

In June 1978 a pair of Golden Eagles nested in this watershed and a pair of Bald Eagles was observed in Dolomite Creek valley. One whistling swan was seen on Isabella Lake throughout June and August 1978.

Management

The caribou population of the Siffleur watershed is a unique resource, being the southern-most occurrence of this species in the Rocky Mountains and the only population south of the North Saskatchewan River. It is unlikely that this herd has contact with any other caribou population; consequently it is in a fragile situation both with regard to its limited genetic pool and its susceptibility to catastrophic mortality. Protection of the mature spruce-fir forests of this watershed should receive high priority in order to assure continued habitat availability. A limited access ecoregion adjoining the park will ensure the herd's continued isolation from disturbance and poaching. Since these caribou are known to range outside the park into the Kootenay Plains area they are vulnerable to habitat loss, disturbance, poaching and native hunting in that area, and cooperative management is essential to ensure their future.

MISTAYA RIVER WATERSHED

This watershed lies entirely within the main ranges of Banff and is bounded on the west and east by steep, rugged mountains (Figure 1.1). In the upper two-thirds of the valley there are a series of large glacier-fed lakes, including Peyto and Waterfowl Lakes. Numerous glaciers, such as the Peyto and Barbette Glaciers, occupy the mountains of the Continental Divide. The Mistaya River has cut a deep narrow canyon where it degrades to join the North Saskatchewan.

Engelmann spruce-subalpine fir forests cover much of the watershed, however, some areas have been burned in the past and are covered by forests of lodgepole pine and lodgepole pine-spruce such as in the vicinity of Upper Waterfowl Lake. The alpine is of limited occurence in this predominately subalpine watershed. A small portion of the drainage in the vicinity of the confluence of the Mistaya North Saskatchewan River lies in the montane ecoregion.

The Icefields Parkway passes through the Mistaya valley and a campground is located between Upper and Lower Waterfowl Lakes. An abandoned gravel road runs from Bow Summit to Upper Waterfowl Lake. Sections of this road are also found in the lower Mistaya valley.

Wildlife

Deer, moose, elk and goat are found in this watershed. Deer, moose and elk use the area primarily in summer; winter track count transects show low use of the area in winter.

Moose are common in this watershed from at least May to September. In spring 1978, five to eight moose were observed during regular evening surveys along the highway. In September rutting bulls were commonly seen along the roadside. Warden

records for the 1940's and 1950's indicate that up to 9 moose were present at Upper Waterfowl Lake. Nineteen moose were said to be in the Mistaya District in October 1959 (Warden records).

Few elk were observed in the area but pellet counts showed moderate use of forested areas. Warden records report herds of up to 30 elk in the watershed in the 1950's and 1960's. Historically, the Mistaya is one of the corridors through which the introduced elk of the Bow valley gained access to the North Saskatchewan valley, but there is little good elk habitat in the watershed.

Goats, in scattered bands of one to five, were seen on the slopes of Mts. Murchison, Noyes, Chephren and Synge during surveys from May through September 1978. Warden records indicate herds of 12-15 goats on Mt. Murchison and Mt. Noyes in the 1950's and 1960's.

No sheep were seen in this watershed during the inventory and there are no warden records of sheep here.

In summer, coyotes are commonly seen in Waterfowl campground area (warden records). Very few tracks were recorded in winter.

Winter track counts revealed wolves in the northern part of the watershed. Wolf records in winter may represent sporadic intrusions by wolves from the North Saskatchewan valley. There are few warden records of wolves in the valley. In October 1959 a wolf track was reported from Totem Creek. A wolf track was observed on the Chephren Lake trail in August 1972.

Black bears are fairly common in this area and Waterfowl Campground has always been a major attractant to them. A new garbage-handling procedure may break this historical pattern of use. Clarke (1940) notes, "The region was one formerly famous for grizzlies but there were no fresh signs to be seen." He attributes this to the Mistaya valley, once known as Bear valley, being "dominated by the new Jasper Highway". Grizzly bears occur at low densities now, mostly at high elevations (Warden records).

Short-tailed weasels are uncommon, and marten occur at moderate densities in Engelmann spruce-subalpine fir forests along the valley bottom. Tracks of long-tailed weasels were observed in a lodgepole pine forest near Upper Waterfowl Lake and in a lower subalpine shrub meadow near Lower Waterfowl Lake. Wolverines are widespread but uncommon and this watershed is one of the few areas in Banff where fisher occur.

The common small mammal species of Banff were found in this watershed during trapping surveys. Flying squirrels were found in Engelmann spruce-subalpine fir forest near Waterfowl Lakes. A beaver was observed in Upper Waterfowl Lake during the summer of 1978, however the declining water level during the winter forced the animal to leave and it was killed by coyotes.

The lakes of the watershed are used by small numbers of migrating waterfowl including Red-necked Grebe, Western Grebe, Canada Goose, Pintail, Green-winged Teal, Lesser Scaup and Ruddy Duck. In July 1978 three black swifts were observed in the vicinity of the Mistaya Canyon, but there is no evidence yet that this rare species breeds there.

Management

The apparent decline in the number of moose frequenting this watershed since the middle part of the century may be a factor of habitat loss as shrubby old burns have given way to dense lodgepole pine forest. The limited development of this watershed, and the extent of its coniferous cover, suggest that "laissez-faire" fire management, or controlled burning, may be feasible; these would result in more year-round moose habitat and summer range for elk and deer.

NORTH SASKATCHEWAN RIVER WATERSHED

This large watershed lies mainly in the Main Ranges and is situated at the north end of Banff (Figure 1.1). This drainage includes the valleys of the Howse, Glacier and Alexandra Rivers and Arctomys Creek, as well as several extensive icefields, including the Freshfield, Mons and Columbia. Of the montane ecoregion of Banff, 19% occurs in this drainage, in the lower North Saskatchewan valley and along the Howse River to its confluence with the Glacier River. The remainder of the watershed is mainly subalpine though there are some extensive alpine areas including the Castleguard Meadows, Parker's Ridge and parts of Sunset Pass

Much of the lower and upper Saskatchewan valley and parts of the Howse were burned 60-80 years ago and are covered with lodgepole pine and lodgepole pine-spruce forest. The slopes of Survey Peak were burned in 1940. shrub-dominated burn forests are found on the slopes of Mt. Wilson and aspen forest is found on some of the lower slopes of Mt. Coleman and Mt. Wilson. Engelmann spruce-subalpine fir forest covers most of the tributary valleys and there are shrub-dominated burns in some upper subalpine areas.

The Icefields Parkway follows the North Saskatchewan River valley. Other developments include a bungalow resort, restaurant and service station, visitor services centre and an abandoned fire-road that goes up the Alexandra River valley. There is one back-country warden cabin, in the Howse River valley.

Wildlife

All ungulates that occur in Banff and Jasper have been recorded in this watershed. No caribou or caribou sign were observed during the inventory but there are three warden records of caribou. In June 1966 a caribou was seen near the Weeping Wall, one was observed at Parker's Ridge in January 1974, and six were seen on Cirrus Mountain in August 1969

White-tailed deer have occasionally been seen in the area since the 1940's. Mule deer are also scarce in the watershed and only one was seen during the inventory, in the upper North Saskatchewan River area. There are several warden sightings of mule deer between 1940 and 1963, but none after that time. Winter track count transects showed no deer in the Howse or Alexandra valleys and only low track densities in the North Saskatchewan River valley.

Few moose were observed during the inventory and sightings were concentrated along the highway in the lower and upper North Saskatchewan area. Winter track count transects showed low use of the Alexandra and upper North Saskatchewan area and no tracks in the Howse or lower North Saskatchewan. However, a Warden Service aerial survey in November 1976 found three moose in the Freshfield area of the Howse River valley. Warden records indicate that moose were more common in the 1950's and 1960's. For example, in June 1956 fourteen moose were reported in the Howse and in September 1963 eleven moose were reported in the Mile 86 area of the Banff Jasper Highway. There is a mineral lick used by moose in the Saskatchewan Crossing area.

Elk use the lower North Saskatchewan and Howse River valleys, principally the montane ecoregion, as summer range. Most of these elk leave the park and move further down the North Saskatchewan to the Kootenay Plains in winter. Low use of the lower North Saskatchewan was revealed by winter track count transects. Warden records report 114 elk by the Icefield Parkway west of Mount Wilson in November 1963. The elk of this area are descendants of elk re-introduced to the Bow valley in 1919 and 1920 and first appeared in the watershed in 1936 (Cowan 1943).

Mount Wilson is one of the most important goat ranges in Banff. Up to 80 goats have been recorded on the rugged terraces of this mountain in late spring. By summer few goats are visible from the highway, and numbers increase again in the Fall. The Parker's Ridge area, at the very northern tip of the park, is another important goat range. Up to 16 goats were seen here in the summer of 1978. Warden records report 19 goats on Parker's Ridge in March 1972. Bands of 3-7 goats were observed at the headwaters of the Glacier River in July 1978.

Sheep occur in the Parker's Ridge - Nigel Creek area in small numbers. The slopes of Mount Wilson are a major range for a sheep population which ranges mostly east of the park boundary. No sheep were seen west of the North Saskatchewan River. Herds of up to 27 rams were observed on Mt. Wilson from June until March. Wardens have recorded up to 36 sheep n the slopes of Mt. Wilson.

In summer coyotes are commonly seen along roadsides in the North Saskatchewan valley. Winter track count transects showed moderate use of the Alexandra and lower North Saskatchewan valleys. Use of the upper North Saskatchewan valley was low and no tracks were seen in the Howse.

Wolves have been present more or less regularly since the 1940's, principally during the winter months (warden records). During the 1940's and early 1950's up to 5 wolves were reported in all parts of the watershed except the Alexandra valley. Sightings between 1951 to the 1970's were less frequent and involved small groups of wolves. Tracks of one wolf were recorded during a winter track count transect in November 1978.

Black bears occur throughout the watershed and are commonly seen along the roadsides in early summer. There are numerous records of black bears frequenting garbage sources in campgrounds and at tourist bungalows in this watershed (warden records).

Grizzly bears are present in low numbers throughout this drainage. Few grizzlies were seen during the inventory but scats and tracks were common along the Alexandra fire road in summer and diggings were common in Columbian ground squirrel and Hoary marmot colonies in the alpine areas of the Howse in July. Historically, garbage-dependent grizzlies used to be more common in the North Saskatchewan valley than they are now. Stelfox (1966) reports that as many as eight bears at once were around the Saskatchewan Bungalows.

Mink are very common in winter along the Alexandra River. Least weasel tracks were recorded in the upper North Saskatchewan valley. Winter track counts showed mink to be very common in the upper Alexandra valley; the track index was much higher than in any other watershed in Banff and Jasper. Least weasel use, from winter track counts, of the upper North Saskatchewan area was the highest in Banff and the second highest of Banff and Jasper. Tracks of these animals were commonest on avalanche slopes along Nigel Creek and on the Alexandra fire-road.

Short-tailed weasels are present in low numbers in the Alexandra and Howse during winter and were not recorded on track count transects in the North Saskatchewan valley. Marten tracks were oserved throughout the watershed during winter surveys, being commonest in the upper North Saskatchewan valley in valley bottom lodgepole pine and lodgepole pine-spruce forests areas as well as on shrubby avalanche slopes. Tracks of a fisher were recorded in a lower subalpine lodgepole pine forest in November.

There have been no sightings of cougar in the area and few sightings of lynx (warden records). Most lynx records are from the upper North Saskatchewan valley.

Management

The North Saskatchewan watershed contains 19% of the montane ecoregion in Banff. Although this montane area is less heavily used by ungulates than the lower Bow and Cascade valleys, further incremental loss of land through facility expansion and development will continue to shrink the already-limited extent of this highly important ecoregion.

Bear management in developed parts of parks is a perpetual dilemma and the North Saskatchewan, as the second most developed part of Banff, has traditionally had its share of garbage-feeding and roadside-begging bears. The lower level of development here than in the Bow valley means this watershed has higher potential for sustaining a relatively natural black bear population; effective garbage handling, and education and policing of the public, are essential if this goal is to be achieved.

Ungulates, bears and wolves using this watershed may be subjected to hunting and other unnatural mortality when they move outside the park; effective monitoring and cooperative management of these populations are required.

ATHABASCA RIVER WATERSHED

The Athabasca River drains most of the central part of Jasper National Park. It rises principally in the Main Ranges and is fed by glaciers to the extent that it remains silty and grey throughout the spring and summer.

Because of the large extent of this watershed, the diversity of its terrain, and the extent to which developments are concentrated here, the entire watershed can not be treated as one. The Snake Indian, Miette, Astoria, Whirlpool, Maligne, Rocky and Fiddle Rivers are major tributaries which are discussed separately below. For the purpose of this discussion the Athabasca watershed includes the main Athabasca River valley, the Sunwapta River, and the valleys of creeks which drain directly into the Athabasca (Figure 1.2).

The lower Athabasca River valley, downstream from Jasper townsite, lies entirely within the Front Ranges and includes the bulk of Jasper's montane ecoregion. The lower Athabasca River flows in a well-developed floodplain with few braided portions. The alluvial fans of the Snake Indian River and Rocky River dam the valley, creating a long shallow lake (Jasper Lake) which is full only from mid-May to mid-August and becomes an exposed, silty plain during the rest of the year. The river flows over gravel bars and log jams below Jasper Lake before slowing down and becoming almost canal-like above the fans of Moosehorn Creek and the Fiddle River.

There are several large lakes and ponds on the lower Athabasca River floodplain, isolated from the river by natural levees or sand spits. There are extensive alluvial fans and floodplain areas covered with willow shrubbery and open spruce forest.

South of the mile 12 bridge on highway 16 there are extensive grasslands on well-drained glaciofluvial terraces, which are bordered with and being invaded by lodgepole pine forest. North of the bridge grasslands occur on southeast-facing alluvial fans (especially the fans of Cobblestone, Corral and Vine Creeks and the Snake Indian River), and on dry slopes and dune areas which are annually enriched with silt blown from the bed of the river and Jasper Lake.

Because of the mild climate and frequent winds in the lower Athabasca River valley, much of the vegetation is open forest. White spruce, lodgepole pine and Douglas-fir are the most abundant tree species. There are few extensive stands of aspen but there are balsam poplar stands on the fans of Garonne and Jacques Creek, and there is a dense tall willow woodland at the latter location, which is known locally as the Mushroom Patch.

The middle Athabasca River valley - between Jasper townsite and Athabasca Falls - lies in the lee of the Main Ranges and is generally less windy and more heavily forested than the lower valley. Although most of the middle Athabasca River valley and its tributaries lie within the subalpine ecoregion, the valley floor and lower slopes are montane. There are large aspen stands between the Icefields Parkway and the lower slopes of Signal Mountain. The broad valley floor is predominantly glaciofluvial terraces and till plains covered with lodgepole pine forest, however the Valley of the Five Lakes area is heavily ridged with Douglas fir/hairy wild rye (C1) forest on the rocky outcrops and willow and sedge meadows in the swales.

Engelmann spruce-subalpine fir forest is confined to upper subalpine slopes and the unburned tributary valleys of Hardisty and Whistler Creek. Portal Creek is a major tributary valley which was extensively burned in the past and is now full of open shrubby slopes with scattered young lodgepole pine.

There are large expanses of alpine terrain at the head of Whistlers, Portal, Hardisty and Tekarra Creek and along the Maligne Range.

The upper Athabasca River, upstream from Athabasca Falls, lies entirely within the Main Ranges. The montane ecoregion extends into the upper valley as far upstream as the Ranger Creek fan, with seven large aspen-covered alluvial fans between Athabasca Falls and Ranger Creek. The south and west-facing slopes of Mount Kerkeslin are drier and more open than other slopes in this watershed, with Engelmann spruce-subalpine fir-whitebark pine-lodgepole pine (O4) open forest and steep, grassy slopes.

The valley bottom is broad, with glaciofluvial terraces and rolling till deposits covered with lodgepole pine and lodgepole pine-spruce forest, and black spruce and sedge bogs in hollows. Most of the valley slopes, especially along Fryatt and Lick Creeks and the Athabasca River upstream from the Chaba, are forested with Engelmann spruce-subalpine fir forest and dissected by numerous avalanche slopes. This is a deep snow area, lying near the continental divide and Columbia Icefield, and the avalanche slopes are consequently much lusher than in the Front Ranges. Dense alder thickets and lush herbaceous meadows characterize these slopes in the western part of the watershed.

There are two recent burns. One extends from Fortress Lake along the Chaba River to the Athabasca River and the other is confined to the slopes above Quincy Lake. Both of these areas burned in 1968 are still shrub-dominated burns.

There are no extensive alpine areas but the heads of Fryatt, Lick and Lynx Creeks and the basin north of the Chaba burn contain expanses of open upper subalpine vegetation.

The Sunwapta River is a major headwater tributary of the Athabasca River, draining the southermost part of the park. It is a glacial river carrying runoff and sediment from the Columbia Icefields. The Sunwapta and Beauty Creek flats are broad gravel outwash plains where the braided river winds through gravel flats and sedge meadows and squeezes past the active fans of tributary streams. Elsewhere the Sunwapta River occupies a more confined floodplain but it is a rapid, braided stream along most of its length.

Pine forest predominates in the valley bottom on till veneers; higher up the valley slopes and in the tributary valleys Engelmann spruce-subalpine fir with numerous shrubby avalanche slopes prevail.

There are several extensive alpine areas including the heads of Jonas and Beauty creeks and the Wilcox Pass area. Although this is an area of high snowfall, the vicinity of Sunwapta and Wilcox Passes and Tangle Ridge is not one of deep accumulation, since frequent wind keeps slopes cleared of snow.

The Athabasca River watershed, especially the lower Athabasca River valley, is the most heavily-developed area in Jasper. The CNR main line and the Yellowhead highway transect the lower valley and, since they are on opposite sides of the river over much of this distance, they affect virtually every major ridge and alluvial fan in the montane portion of the lower Athabasca River valley. The Icefields Parkway follows the east side of the middle Athabasca River and similarly transects most of the montane ecoregion there, continuing south through the Sunwapta River valley. There are numerous other developments including scenic roads, a golf course, summer cottage and resort developments, eight campgrounds, a ski resort and a pipeline. Only the upper Athabasca River valley is relatively untouched.

Wildlife

The use of the Athabasca River watershed by wildlife varies markedly from one part of the watershed to the other. In general, the lower reaches of the watershed are most important to ungulates and their predators, to waterfowl, and to many species of birds, while the upper reaches are of more importance to small mammals and their predators, such as martens and wolverines, and to caribou and moose.

The dry, open vegetation of the lower Athabasca River valley provides abundant forage for grazing animals, while the high winds and low snow accumulation of winter allow them better mobility and easier foraging than in the upper reaches of the watershed. In the heavier forests of the upper reaches, winter snow accumulation is higher and - while it excludes all but the best-adapted ungulates, moose and caribou - it provides a sheltered winter microenvironment for subnival rodents and their predators.

The lower Athabasca River valley is one of the most important areas in Banff and Jasper for elk, sheep and deer and, potentially, moose. Only caribou, of all ungulates which occur in Banff and Jasper, have not been recorded here. Winter ungulate track densities were distinctly higher around Jasper townsite (107.10 tracks/10 km-days) and the lower Athabasca River (57.09) than in the middle Athabasca River (13.22), middle Athabasca River (5.44) and Sunwapta River (0.95) valleys.

There are 6 major winter ranges of bighorn sheep in the lower Athabasca River valley and almost half of Jasper's total sheep population winters here (Stelfox 1978) (Figure 3.55). These winter ranges are all truncated by one or the other of highway 16 and the CNR railroad. Collisions create a constant drain on these population and have been identified as the major factor in the on-going decline of at least one of these (Van Tighem 1980). Sheep formerly occurred in the upper Portal and Whistler Creek valleys but this population was extirpated by hard winters and disease during the late 1940's; at the same time a population which had formerly wintered on Mount Kerkeslin also disappeared (Stelfox 1978). There are about 50 sheep still present on the Maligne Range and another small population which frequents the windswept slopes of Tangle Ridge and Wilcox Peak above the Sunwapta River.

Elk occur throughout the Athabasca River watershed but are scarce in the Sunwapta River and upper Athabasca River valleys, as well as the tributaries feeding the middle Athabasca River from the west. In autumn the Marmot Basin ski hill, the Lakes Annette and Edith area, the valley of Five Lakes and the vicinity of Whistlers and Wapiti Campgrounds are used by rutting elk. Elk winter throughout the lower and middle Athabasca River valley downstream from Ranger Creek. Areas of major importance include the slopes and flats between the Palisade and Snaring warden station; the slopes and flats between Windy Point and Moosehorn Creek; the dunes and river floodplain from Edna Lake to the Jasper east gate; and the area between Whistlers Campground and Wabasso Lake. Small groups of bulls winter in the valley of Five Lakes and as far upstream as Ranger Creek. Fourteen elk wintered on the Beauty Creek flats along the Sunwapta River in 1979 and 1980. Six were killed by poachers the first winter and the remainder were apparently killed by wolves the following winter (R. West, Jasper warden service, pers. comm.). A major mortality factor, particularly during years of heavy snowfall, is collisions with trains and automobiles (Van Tighem 1980, Damas and Smith

1982, park warden files).

Mule deer occur throughout the Athabasca River watershed but are commonest in the eastern-most parts of the watershed and downstream from Jasper townsite. Major wintering areas include Jasper townsite and the entire south and east facing lower slopes of the valley downstream from there. Whitetails are rare upstream from Jasper townsite but are more abundant and regularly seen downstream from Jasper Lake than anywhere else in Jasper. Deer mortality is seven times higher on the CNR line in Jasper than on the CPR line in Banff because the CNR transects virtually the entire length of the most important winter and spring mule deer habitat in Jasper.

Moose are uncommon along the lower Athabasca River although suitable habitat in the form of alluvial wetlands, upland bog forests, and open coniferous forest is abundant. For instance, from 2 to 5 moose regularly winter on the Jacques Creek fan. Populations are now far lower than described by Soper (1970) and high railroad and highway mortality has been a major factor in the decline. The highest densities of moose in the Athabasca River watershed are along the upper Athabasca River and Sunwapta River valleys where shrubby meadows along stream floodplains and on avalanche slopes provide year-round forage, and both traffic collisions and predation are low.

Mountain goats occur at low densities throughout the Athabasca River watershed, but are most common on the slopes of Mount Kerkeslin above the upper Athabasca River. wintering areas include Tangle Ridge, Mount Kerkeslin, Marmot and Whistler Basins, and Greenock mountain.

Mineral licks at the Cold Sulphur Springs, Edna Lake, Disaster Point and the base of Greenock Mountain are used primarily by sheep, particularly nursery bands. A lick near Athabasca Falls on the banks of the Athabasca River is a popular spot for viewing goats. These licks bring ungulates into frequent contact with vehicle traffic in summer, when traffic is heaviest (Van Tighem 1980). Lick Creek is named for a large dry mineral lick near its confluence with the Athabasca River, opposite the Athabasca Falls lick.

Woodland caribou occur in summer in upper Portal Creek and along the Maligne Range, and throughout the upper Athabasca River and Sunwapta River drainage. They are nowhere abundant and are considered to be declining (Stelfox et al. 1978). In winter Woodland caribou are seen regularly along the Maligne Range and on Beauty Flats. They winter in upper whistler and Portal Creeks and in the neighboring Astoria and Whirlpool valleys.

Large carnivores, including coyote, wolf and cougar, occur more commonly in the lower Athabasca River valley than anywhere else in Jasper, due largely to the abundance and variety of ungulates as well as to the mild climate and the extent of the valley. Wolves probably den near Jasper Lake and near the mouth of the Maligne River. Young pups have been observed at rendezvous sites near both these areas since 1978. At least 25 wolves range the valley in winter. These include three packs that also range into adjacent watersheds. Winter tracking revealed a density of 3.26 wolf tracks/10km-days, higher than anywhere else in Banff and Jasper except the Snake Indian River and Rock Creek drainages. Wolf track densities in the middle and upper Athabasca River valleys were only 1.95 and 1.69 /10km-days respectively. Similarly, coyotes are more abundant in the montane lower Athabasca River valley (7.08 tracks/10km-days) than in the middle or upper portions of the watershed (4.14 and 0.75 tracks/10km-days respectively).

Cougars, though very rare in Jasper, are most regularly seen in the lower Athabasca River valley. Black bears are uncommon in the Athabasca River valley. Most Black bears that forage in campgrounds are ultimately killed, resulting in a permanent drain on the population. There is a wild Black bear population which is resident mostly on the river flats between Devona and Bedson Ridge and black bears are present in low densities throughout the middle and upper Athabasca River valley. Grizzlies forage in the valley bottoms during spring and are then uncommon until late summer when they become increasingly common at the Jasper sanitary landfill. This landfill was successfully enclosed

with an electric fence in 1981 and grizzlies were observed in the Athabasca River valley all summer (J.Woodrow, Jasper warden service, pers. comm.).

Otters formerly occupied Talbot and Edna Lakes but were apparently exterminated by traffic on highway 16. Mink are somewhat less abundant in the lower Athabasca River valley than along the middle Athabasca River (0.57 and 7.13 tracks/10km-days, respectively) but Short-tailed weasels are more abundant here than elsewhere in the watershed (2.77 tracks/10km-days compared to 2.64 and 1.88 in the middle and upper Athabasca River valleys respectively). No wolverine tracks were recorded on winter tracking transects, however they are present in low densities in all but the montane portions of the Athabasca River valley.

Marten are more abundant in the Sunwapta River (27.62 tracks/10km-days) and upper Athabasca River (29.46)- where small mammal populations are relatively high and stable due to the heavy winter snow accumulation- than in the middle Athabasca River (10.34) and lower Athabasca River (4.32) valleys.

The lower Athabasca River is the most important area in Jasper for beavers and muskrats. Beavers den in bank burrows and lodges along the river and the channels and control water levels of floodplain lakes such as Edna and Talbot Lakes by damming. There are extensive beaver dam systems along Tekarra and Cottonwood Creeks and isolated colonies as far upstream as the confluence of the Chaba River.

Because it contains the bulk of Jasper's montane habitats and provides a direct link into the boreal forest region of northern Alberta, and because of the extent of its floodplain lakes and wetlands, the valley of the lower Athabasca River is the most important area in Banff and Jasper for a number of species of birds. Several pairs of ospreys nest here and bald eagles formerly nested in two sites along the lower Athabasca River. Maximum single-day counts of migrant waterfowl along a survey route in the lower Athabasca River valley were 324 in spring and 445 in autumn. The most important areas for waterfowl include:

Pocahontas Ponds
Mile 18 Pond
Talbot Lake
Lakes Agnes,Annette and Beauvert
Snaring Lake

The only significant shorebird migration in Jasper occurs here. A number of rare species, including Buff-breasted Sandpiper, Semipalmated Plover, Western Sandpiper, Mew Gull, Thayer's Gull, Sabine's Gull, Parasitic Jaeger and Long-tailed Jaeger have been recorded only in the lower Athabasca River valley. Important areas for shorebirds and gulls include:

Jasper Lake
Mile 18 Pond
Jasper sanitary landfill

A number of species of boreal distribution that occur nowhere else in Banff and Jasper occur in this area. Among the species which are rare or absent elsewhere but which occur here are Ovenbird (Eastgate, Mushroom Patch), White-throated Sparrow (Pocahontas Ponds, Mushroom Patch, Talbot Lake), Leconte's Sparrow (Pocahontas Ponds), Clay-coloured Sparrow, and Red-eyed Vireo (Mushroom Patch).

Aspen forest and tall willow woodland, with their associated bird communities, are largely confined to the montane ecoregion of the Athabasca River watershed. The only extensive montane grasslands in Banff and Jasper occur here.

Pocahontas Ponds support the only known population of Boreal chorus frogs in Banff and Jasper.

Management

The high importance of the Athabasca River watershed, especially the lower Athabasca River valley, to a wide variety of wildlife, combined with the concentration of the bulk of Jasper's developed facilities and recreational use in this area, results in a plethora of management problems and paradoxes.

The major impact of human use of this watershed on animals is the excessive mortality of ungulates along CNR and Yellowhead highway. One population of sheep is in immediate danger of extirpation and at least four others are declining, primarily due to mortality on the railroad and highway. There is evidence to suggest that a pronounced reduction in moose numbers and a slow decline in elk populations may also be largely due to this source of mortality. The extent of the problem cannot be clearly identified since records of mortality are not consistently maintained and animals killed in collisions are not searched for. In the winter of 1979/80 less than a third of all animals killed on the CNR line near Jasper were reported by park wardens (Van Tighem 1980).

The importance of the lower Athabasca River valley, especially the south and east-facing slopes between Jasper townsite and Bedson Ridge, to wintering ungulates is such that increased winter recreational use of this area should not be encouraged and effective means of reducing the impact of the CNR and Yellowhead highway on ungulate populations should be developed immediately.

Bear management in heavily-populated areas is a chronic problem in national parks and Jasper is no exception. Recent electrification of the fence around the Jasper sanitary landfill and some attempts to enforce garbage disposal regulations may to some extent reduce the attractiveness of the developed areas to bears, but a review of park files shows that garbage control has been an acknowledged problem since the park was established. In 1979 up to 22 grizzly bears were using the Jasper sanitary landfill each night and a memo was posted in the warden office authorizing wardens to destroy any bears in the townsite area. There have been no garbage-related convictions of park residents or businesses. Jasper townsite and the Whistlers and Wapiti Campgrounds are at a major intersection of valley systems, in good black bear habitat, and have become perpetual drains on Jasper's bear population due to control actions required to keep campers safe from scavenging bears attracted to garbage (section). Only a major committment to proper garbage handling by the park and park business and residents, backed up by a willingness to prosecute offending businesses and individuals, will reduce this problem to a level where the Athabasca River valley will again be able to support a viable, wild black bear population.

There has been an undetermined loss of wintering habitat for mountain goats and, especially, caribou as a consequence of the development of Marmot Basin ski area. Further losses can be avoided by limiting further expansion, and by protecting important wintering areas on the Maligne Range, Mount Kerkeslin, Parker's Ridge and Mount Wilcox from similar intensive use.

The wetlands of the lower Athabasca River valley are critical habitat for migrant waterfowl and shorebirds and for a large number of birds that occurs almost nowhere else in Banff and Jasper. The preservation of natural water quality and flow regimes will maintain these habitats.

MIETTE RiVER WATERSHED

The Miette River drains the Main Ranges of Jasper. Its major tributaries include Derr, Minaga, Clairvaux and Meadow Creeks (Figure 1.2).

The Miette River watershed consists of a wide montane lower valley and a somewhat narrower subalpine upper valley. The upper valley runs parallell to the continental divide to an open upper subalpine headwaters region where passes give access to BC and the Snaring River watershed.

An extensive fire history, which has been described in detail by LaRoi et al. (1975), has led to the dominance in the Miette River watershed of dense, faunistically-poor lodgepole pine forests. The ridged aspect of the lower valley, however, produces numerous small lakes and wetlands which are bordered by sedge meadows and willow stands. In addition, the fans of Meadow and Clairvaux Creeks dam the narrow floodplain of the Miette River, backing up extensive marshes and overflow ponds upstream. These backwaters are a mosaic of willow stands, sedges meadows, spruce forests and small ponds.

There is a small natural grassland and aspen forest at Decoigne and scattered stands of aspen and balsam poplar along the Miette River. The alluvial fan of the Miette River where it enters the Athabasca River below the highway 16 bridge is a very productive area of balsam poplar-white spruce forest and tall willow woodland.

The upper valley slopes, the Clairvaux valley and upper Derr Creek and Miette River are covered with dense Engelmann spruce-subalpine fir forest. There are also extensive alpine areas from Elysium Pass to the head of Derr Creek and at the heads of Clairvaux and Meadow Creeks.

This watershed has been heavily developed. It is transected by the CNR main line and the Yellowhead highway as well as several horse and foot trails. There is a warden station at Decoigne, a campground, and a picnic site. There is one back country patrol cabin, opposite the mouth of Rink Brook.

Wildlife

Moose, goat, caribou and Mule deer are the major ungulates of the Miette River watershed. Elk summer in the watershed but are uncommon in winter when small numbers, usually bulls, winter as far up the Miette River as Decoigne and Dominion Prairie. In the mid-1950's bighorn sheep from the Graveyard herd sometimes wandered as far as Wynd siding from the winter range north of Jasper townsite. Roy Hargreaves hunted sheep near the Miette River headwaters in the 1920's (Stelfox 1978), but they no longer occur in the Miette River watershed.

Moose summer throughout this watershed and winter in the montane wetlands and shrub meadows along the Miette River and the ridged terrain to the north of the lower Miette River. Populations of moose have declined in the last twenty years due to collisions with trains and to forest succession on old burns.

Caribou occur from Elysium Pass to the headwaters of the Miette River at all seasons and at the headwaters of Clairvaux Creek in summer. Small populations of mountain goat frequent the Park and Victoria Cross Ranges. Mule deer distribution in summer is not known, but they winter along the south-facing lower slopes of the valley from Decoigne to the Jasper townsite area.

Wolves have denned near Decoigne in the past (Carbyn 1972b) and may have denned in the area in 1980 (T. Damm, Jasper Warden Service, pers. comm.). In winter wolves travel through the valley regularly but rarely go farther up the Miette River than Yellowhead Pass. Coyotes are less common here than in the Athabasca River valley, being confined mostly to the montane valley bottom. Lynx tracks were recorded three times during the winter of 1978/79 (inventory files).

Mustelids are common in the Miette River valley, with moderate densities of Short-tailed weasel, American marten and Wolverine in all parts of the watershed except montane portions. Mink winter along Meadow Creek and the lower Miette.

Golden Eagles nest near the head of the Miette River. The wetlands of the lower Miette River support at least two nesting pairs of ospreys. They are important habitat for waterfowl and passerines and sustain several colonies of beavers and muskrats. The lakes and ponds of the Pyramid bench sustain the bulk of Banff and Jasper's Common

Loon population as well as breeding Barrow's Goldeneyes, beaver and mink.

Management

The CNR line kills many ungulates and has been a major factor, with habitat loss to forest succession, in the on-going decline in moose population in this watershed. Twin-tracking of the railroad may cause increased mortality of wildlife or may - if apprropiate mitigations are put in place - reduce kills to a more acceptable level.

Fire control, subsequent to the extensive fires of the early part of this century, has led to much of this watershed being covered by dense, unproductive lodgepole pine forest. A *laissez-faire* fire policy or an active programme of prescribed burning would increase the heterogeneity of the valley's vegetation and increase its potential for many wildlife species.

There should be no further expansion of Jasper townsite to the west since this would encroach further on highly important montane alluvial fans and south-facing slopes. These habitats are scarce already in Banff and Jasper and further incremental losses are not desirable.

ASTORIA RIVER WATERSHED

The Astoria River is a tributary of the Athabasca River, draining the Tonquin and Eremite valleys of the Main Ranges of central Jasper National Park (Figure 1.2). A scenic road gives access to Cavell Lake from highway 93A. All other access is by trail; nonetheless, the Astoria River watershed receives heavy recreational use at all seasons by hikers, horse parties, skiers and snowmobilers travelling into the Tonquin valley where there are three outfitters' cabin camps, an Alpine Club of Canada lodge, and two primitive campsites, in addition to two warden patrol cabins.

The Astoria River watershed is characterized by steep-sided subalpine valleys covered in Engelmann spruce-subalpine fir forest, and by extensive alpine and upper subalpine meadows in the headwater basins. The Tonquin valley is a broad upper subalpine valley with meadows and open Engelmann spruce-subalpine fir forest surrounding Amethyst Lakes. Precipitation is heavy in all parts of this watershed in summer and in winter.

Lodgepole pine forest is confined to the lower Astoria River valley near its confluence with the Athabasca River. In the vicinity of Cavell Lake and along the first three kilometers of the Tonquin trail there is an extensive Engelmann spruce-whitebark pine/false azalea (C12) forest which supports a population of Clark's Nutcracker and is used in winter by Woodland caribou.

Wildlife

All ungulates which occur in Banff and Jasper have been recorded in the Astoria River watershed, however there is only one white-tailed deer record, two bucks seen on 13 October 1975 near the confluence of the Astoria River and Athabasca River (JST, Jasper warden card). Likewise, the only Mule deer record is of two bucks seen on 11 June 1972 in the same vicinity (Jasper warden card).

Bighorn sheep formerly ranged between the Astoria River and Whistlers Creek, however they were extirpated, probably by severe winters, in the late 1940's (Stelfox 1978; A. Burstrom, Jasper warden service, pers. comm.)

This watershed has historically been one of the major Woodland caribou ranges in Jasper (Stelfox 1978; A. Burstrom, Jasper warden service, pers. comm.). Populations declined from 186 in 1961 to 50-75 in 1969 (Stelfox 1978). The largest count during the inventory was 38 on 11 August 1979 in th Tonquin valley and the present population

is probably less than 50. The Cavell meadows are a traditional calving area. In summer Woodland caribou range throughout Campus Pass, the upper Eremite valley, and the alpine areas above the Tonquin valley. Winter range includes the heavy forests along the Astoria River and the Cavell Meadows. Caribou in this area are subject to disturbance by hikers in their calving and summer ranges, and by snowmobile and skiers in their winter range.

Moose are uncommon, remaining in the area all year long. Tracks of two moose were seen above Amethyst Lakes in late November 1978. The deep snow accumulation typical of this watershed precludes an abundance of ungulates.

Goats occur in low numbers on all the mountains of the Astoria River watershed.

Wolves, coyotes and cougars are very scarce in the Astoria River valley. None were recorded on 128.3 km-day of winter track transects; deep snow and scarcity of ungulates create an undesirable environment for large carnivores. Grizzlies are present in low densities.

Mustelids are fairly common, being dependent on rodents to a greater extent than the larger carnivores. Rodents are favored by the consistently heavy winter snow cover which insulates them from the wind and cold. Mink tracks and droppings were observed in the Tonquin meadows in July 1978 while rainbow trout were spawning in the small streams in the valley. Low densities of Short-tailed weasels (3.35 tracks/10km-days) and moderate densities of marten (16.52 tracks/10km-days) were recorded during the winter.

Amethyst Lakes is the site of two Gray-cheeked Thrush observations in June 1976 (A. Strepniewski) and June 1978 (DJH, MAS). This northern boreal species had not been recorded in the Northern Rockies since at least 1945 (Haddow et al. 1978) but has since been recorded in the upper Miette River valley as well (GRB).

Flocks of both White-tailed Ptarmigan and Willow Ptarmigan make extensive use of the Tonquin valley meadows in winter.

Management

The Astoria River watershed is one which has historically supported a large population of caribou which ranges into Mount Robson Provincial Park, B.C., and into other Jasper drainages, but does not disperse into areas where logging and mineral exploitation would affect them. Consequently this population is one of the few caribou herds in western North America which may avoid the combined ravages of habitat loss and overhunting which have decimated herds in B.C. and northern Alberta (Bloomfield 1979, 1980b). The protection of this population from excessive harassment and disturbance, particularly in summer, is critical to its ongoing well-being (Stelfox 1978). Further development of the calving areas in the Cavell meadows and of summer range above the Tonquin valley should be avoided. Snowmobile use in winter, in addition to disturbing wintering caribou, may create barriers to their movements (Bloomfield 1978) and provides packed trails which are used by wolves to range into areas where they would otherwise not go.

The sedge meadows near Amethyst Lakes are severely overgrazed and trampled by horses, rendering them of little or no use to ungulates such as caribou and greatly decreasing their productivity of small rodents.

WHIRLPOOL RIVER WATERSHED

The Whirlpool River is a major tributary of the Athabasca River. Its valley is undeveloped except for a short fire road and a warden patrol cabin. The route along the Whirlpool River over Athabasca Pass was once a major fur-trading trail. Today the trail is used only occasionally by backpackers and much of the watershed is never visited.

The Whirlpool River is a turbulent glacial river that drains the glaciers of the Continental Divide. Its valley is broad but its floodplain is narrow except for some braided portions below Scott Creek and some widenings above the fan of the middle fork and near Tie Camp. There are alluvial meadows along Simon Creek and the Middle Fork, above the points where the streams begin to drop down into the main valley.

Wildlife

Ungulate use of the Whirlpool River drainage is generally low, probably because of its winter snow accumulation and the predominance of closed forest. Goats and moose are the most widespread ungulates, occurring at low densities in all parts of the watershed. There is a major lick used mostly by goats along the canyon of the Middle Fork.

Elk are scarce in summer and only a few remain in winter in the vicinity of Tie Camp and downstream to the Athabasca River. Mule deer are similarly uncommon but have been observed in winter (13 January 1979) at least as far upstream as Scott Creek. There are no reports of white-tailed deer or sheep in this watershed.

Caribou have been recorded near the head of the Middle Fork and Simon Creek and along the northern edge of the watershed. These are part of the Tonquin valley/Cavell meadows population and winter on the slopes below Mount Edith Cavell and Chevron Mountain (A. Loewen, JNP warden service, pers. comm.).

Wolves occur in the Whirlpool River valley throughout the year and may den along its lower reaches. In winter they range as far upstream as Simon Creek. There are low to moderate densities of weasels, martens and wolverines, and several Long-tailed weasel tracks were observed on Verdant Pass in December 1978.

Beaver colonies are present along the Middle Fork and Simon Creek. The avifauna of the Whirlpool River watershed is similar to that of other subalpine drainages. Unusual species recorded here include Parasitic Jaeger, Wood Duck, and Hawk Owl.

Management

There are no major management concerns in this watershed. Its large extent and low human visitation currently render its wildlife safe from excessive disturbance.

MALIGNE RIVER WATERSHED

The Maligne River drains the south-central part of Jasper National Park and rises in the glaciers and snowfields of the Maligne and Queen Elizabeth Ranges (Figure 1.2). A scenic road that runs from the Yellowhead highway south to Maligne Lake provides access to such popular attractions as Maligne Canyon, Medicine Lake, Maligne Lake, and the Skyline and Jacques Lake trails. There are no overnight campgrounds and the only developed facilities are at Maligne Lake.

Engelmann spruce-subalpine fir forest is confined to the upper slopes of the Maligne Range and parts of the Queen Elizabeth Ranges; most of the lower valley and southwest facing slopes are covered with fire-succession lodgepole pine and lodgepole pine-spruce forest. The valleys of the upper Maligne River and its tributaries above Maligne Lake have extensive cold-air drainage meadows with open lodgepole pine-spruce and Engelmann spruce-subalpine fir forest on the mid-slopes. There are vast tracts of upper subalpine and alpine meadows in Maligne Pass and along the Maligne Range. The Queen Elizabeth Ranges are generally steep and rocky with few extensive meadows or forests.

Medicine Lake, unlike Maligne Lake, fluctuates dramatically during the year due to drainage through sinkholes in the lake bed. The Maligne River immediately below Medicine

Lake is dry except in mid and late summer, but is recharged by springs and tributaries by the time it reaches Maligne Canyon where it degrades rapidly to reach the elevation of the Athabasca River.

The montane ecoregion extends only a short distance up the lower Maligne River above the canyon, and the rest of the watershed is mainly subalpine. Snow accumulation is heavy in the upper Maligne River valley and the road is kept open by ploughing, sanding and salting in winter to give access to the cross country skiing of the upper valley.

Wildlife

Every species of ungulate which occurs in Banff and Jasper has been recorded in the Maligne wateshed. Only the white-tailed deer is rare, being limited mostly to the lower Maligne River and not having been recorded in winter.

A small population of bighorn sheep summer along the Maligne Range and move in winter to the northwest end of the range around Old Fort Point. Although up to 10 rams have been recorded in winter on steep, grassy slopes near the Opal Hills, most of the sheep that summer on the Queen Elizabeth Range winter farther east in the Rocky River drainage. Sheep occur in summer along the Colin Range and around Maligne Pass, but most of these also leave the Maligne watershed in winter. There is a rutting and winter range above Maligne Canyon. Mountain goats are present in low numbers in all the mountains of this watershed.

During 206.1 km-day of winter tracking in the Maligne watershed, caribou tracks were recorded only along the upper Maligne River (7.00 tracks/10km-days) and deer tracks only along the lower Maligne River (3.90 tracks/10km-days). Although no elk tracks were recorded, there are records of elk occurring sporadically as far up-valley as Medicine Lake in winter; most migrate to the lower Athabasca River valley. In summer elk occur throughout the Maligne watershed.

Mule deer are most common on the Colin and Queen Elizabeth Ranges although they range in summer throughout the watershed. The lower slopes of the Colin Range are a major wintering area.

Caribou range in summer all along the Maligne Range but have been recorded east of the Maligne River. The mature subalpine forests of the upper Maligne River valley and the slopes above Medicine Lake are a major winter range and caribou have been observed in winter eating salt on the Maligne Road. The delta of Medicine Lake is a traditional, highly-favoured spring caribou range.

Moose winter in the upper Maligne River valley and the Summit Lakes area and are widespread in the Maligne watershed in summer. This is one of the most important watersheds in Jasper for moose.

Carnivore distribution in the Maligne watershed exhibits a similar pattern to what is found in other Banff and Jasper valleys. Wolves (7.14 tracks/10km-days) and coyotes (1.02) are more abundant in the middle Maligne River valley than in the upper parts of the watershed where snow accumulation is too deep (2.64 and 0.88 respectively). Conversely, martens (35.70) and short-tailed weasels (5.04) are most abundant along the upper Maligne River and less abundant (6.46 and 1.02 respectively) along the middle Maligne River. Wolverines occur throughout the watershed at low densities. The upper Maligne River valley supports one of the highest densities of martens in Banff and Jasper.

Cougars have been observed in the past near Maligne Canyon and Fifth Bridge. One of the few recent cougar records was one reported twice along the lower end of the Watchtower trail during the winter of 1979/80.

Maligne Canyon is one of only two known breeding sites of the Black Swift in Alberta and is used by up to four pairs of nesting ravens. The open water at the outlet

of Maligne Lake is important to wintering dippers and occasional goldeneyes and other ducks. Osprey nests at Medicine and Maligne Lakes are the only known nests in the subalpine ecoregion in Banff and Jasper. Six Boreal Owls were recorded near Medicine Lake in 1980, an unusually high number.

Management

The Maligne caribou population is the only one in Banff and Jasper which is known to remain in the park at all times of the year. Consequently it is not subjected to hunting, habitat loss due to logging and mineral development, and other pressures that have been implicated in the ongoing decline of Alberta's caribou populations (Bloomfield 1980c). As long as the critical caribou habitat west of the Maligne River and at the mouth of Medicine Lake is protected from development or increased recreational use, this population will remain of considerable scientific interest. No campgrounds, picnic sites or other facilities should be developed west of the Maligne road above Medicine Lake if this population is to be protected adequately. Although forest fires may be desirable in some parts of Banff and Jasper, protection of the forests west of the Maligne River and Medicine Lake is essential to preserve caribou winter range.

Potential disturbance of wintering moose and caribou should be taken into account when park staff are laying track for cross-country skiing. This is especially critical since wolves commonly travel on snowmobile and ski trails to reach areas that would otherwise be inaccessible.

BRAZEAU RIVER WATERSHED

The Brazeau River rises in the snowfields and glaciers of Le Grand Brazeau and flows east, forming the south boundary of Jasper National Park (Figure 1.2). The north fork drains a large icefield and a vast expanse of rocky alpine meadows and flows in a braided channel to Brazeau Lake. The south fork also drains a number of extensive alpine areas, joining the north fork at the Brazeau District warden station. Downstream from the junction expanses of marshy floodplain alternate with narrow gorges and canyons. The most extensive backwater areas, with sedge meadows, oxbow ponds, willow flats and spruce forest, occur upstream of Arete and Isaac Creeks.

Lodgepole pine forest is the predominant vegetation of this watershed, with spruce open forest in the wetlands along the river bottom and Engelmann spruce-subalpine fir stands on the steeper slopes and side valleys. As this watershed is mainly within the Front Ranges, the forest is generally open and dry with many grassy slopes and open, formerly-burned areas.

Wildlife

The Brazeau watershed is highly important to many wildlife species. It is one of Jasper's most important ungulate ranges,used year-round by sheep, elk, mule deer, moose and goat. White-tailed deer occur regularly downstream from Brazeau District warden station and caribou occur in the region of Jonas Pass, Marble Mountain and Flat Ridge at all seasons. When elk were virtually exterminated from Alberta by disease and severe winters in the late 1800's, a small population survived in the Brazeau River area (Stelfox et al. 1978). Elk from Montana and Wyoming were used to re-stock the Bow and Athabasca valleys; consequently this drainage is one of the few areas in Alberta where the gene pool of elk still may be relatively natural.

Sheep occur in all parts of the watershed in summer but winter mainly east of Brazeau lake. Isaac Creek contains a large population of sheep all year round. The major elk winter range is along the river flats and open slopes from Arete Creek downstream and along Isaac Creek below Sawtooth cabin, however in winters of below-average snowfall elk may occur as high as the lower slopes of Flat Ridge.

There is a sheep lick along the rim of the Brazeau Canyon near Arete cabin.

The small caribou population in the Brazeau River headwaters region numbered at least 18 in 1955, but the highest count since then is 6 on 30 January 1978 (Jasper wildlife card file). This population probably mixes with or is part of the population ranging along the Maligne Range; a count of 15 on 30 August 1976 on Poboktan Pass may have been from this population. Caribou are found in only two areas south of here in the Rocky Mountains: in the White Goat Wilderness south of the Brazeau River and in the Siffleur Wilderness and adjacent parts of Banff National Park south of the lower North Saskatchewan River.

Wolves den near Arete cabin and have formerly denned near Dowling Ford, and range throughout the watershed at all seasons. Black bears are common along the valley bottoms. The entire watershed is highly important to grizzly bears. Cougars were regularly reported in the 1960's and 1970's and a female with young was seen on 10 March 1972 (Jasper wildlife card file); the only record since 1976 is a track in the winter of 1979/80 (JLK). Higher than average densities of mustelids were recorded in this watershed, and the highest density of Least weasels in Banff and Jasper was recorded here on winter track transects.

Golden Eagles nest in at least two known locations in this watershed. The backwaters and floodplain ponds of the Brazeau River are used by nesting Canada geese and are also important to other waterfowl such as Mallard, Green-winged Teal, Lesser Scaup and Barrow's Goldeneye.

The fan of Isaac Creek is a diverse and productive area where Boreal Owl, Saw-whet Owl, Great Horned Owl and Eastern Phoebe have been observed in May. The sedge meadows upstream from this fan were found to contain at least 6 territorial Leconte's Sparrows on 2 June, 1979 (KVT) and is one of only two probable breeding sites for this species in Banff and Jasper.

Willow Ptarmigan occur near Poboktan Pass and have been recorded south of the park in the Job Creek drainage (KVT).

Management

The Brazeau watershed is undeveloped except for the south Boundary trail system and six warden patrol cabins. Seismic cutlines on provincial land south of the Brazeau River, however, are used by recreationists in all-terrain vehicles and trail bikes during the summer and autumn and by snowmobilers occasionally in winter. Development of a provincial recreational area may increase access into and use of this watershed, with consequent increased disturbance of wildlife and killing of bears attracted to garbage. Poaching along the Brazeau River flats and up major tributaries such as Isaac Creek is an on-going problem that will be aggravated by improved access. It is critical to the ecological integrity of this area that an undeveloped buffer area be maintained on the provincial side of the river to limit access to the valley. The very high importance of this watershed to wildlife warrants special preservation measures.

The importance of this watershed's elk population as a reservoir of native genetic material increases the need for its preservation.

SOUTHESK RIVER WATERSHED

The Southesk River drains the large icefields of the Queen Elizabeth Range and Le Grand Brazeau. Its major tributary, the Cairn River, rises in a series of alpine basins and drops rapidly through a narrow valley to join the Southesk near the southeast corner of Jasper National Park (Figure 1.2).

Virtually the whole Southesk drainage has been burned in the last century. The valley bottoms contain shrubby alluvial meadows and open young lodgepole pine forests. There are extensive high grassy meadows. The dry, wind-blown nature of this Front Range watershed results in slow forest regeneration. Engelmann spruce-subalpine fir timber occurs in bands along the upper slopes but even the mature stands are relatively open compared to areas farther west.

Wildlife

The abundance of grass, shrub and forb-dominated vegetation and low winter snow accumulation make this an important watershed for ungulates. Of all the ungulate species which occur in Banff and Jasper, only caribou and white-tailed deer have not been recorded here.

Sheep occur throughout this watershed in summer and occur in winter along the south fork of the Southesk, on Mount Southesk and the Cairn Pass area and east of the Cairn River, including winter ranges outside the park along Ruby and Thistle Creeks. Goats occur on all the mountains in the watershed but are not common.

Elk are similarly widespread and winter along the lower Southesk and Cairn Rivers. Moose are widespread though not abundant, occurring in most parts of this watershed all year round. The meadows from Southesk Lake upstream to Blow Pass are moose winter range.

Although black bears are uncommon, grizzlies occur throughout the Southesk watershed and this watershed is one of the most important grizzly areas in Jasper. Wolves use the main Southesk valley at least as far upstream as Southesk Lake and have been recorded in Cairn Pass. A cougar with a kitten was observed near the Cairn River on 10 March 1972.

The windswept slopes of this watershed provide generally reliable winter habitat for sheep and goat, but the gentler slopes of the lower valleys accumulate snow to the extent that in some years they may not be suitable range for elk. In December 1962 there were 24 bull elk wintering in the Cairn Pass meadows; the highest recent count was 6 on 26 January 1975 (Jasper wildlife card file) and in January 1980 only two were present (KVT).

Golden eagles nest near Cairn Pass.

Management

The isolated location of this watershed complements its highly productive habitat characteristics to create one of the most important areas in Banff and Jasper for large mammals. The value and ecological integrity of the area are indicated by the presence of such sensitive wilderness species as grizzlies, wolves and bighorn sheep. Maintaining the area's isolation will ensure its continued value to wildlife.

Development of mineral, forest and recreational resources on adjacent provincial land may increase access to and recreational use of this watershed if adequate buffer areas are not ecoregiond. Poaching of bighorn sheep and grizzly bears is already a problem and could be aggravated if access is improved.

ROCKY RIVER WATERSHED

The Rocky River drains the Front Ranges of southern Jasper National Park (Figure 1.2). It is a tributary of the Athabasca River. Lodgepole pine forest and Engelmann spruce-subalpine fir/willow/hairy wild rye (O18) stands predominate along the valley bottoms, with large shrub meadows in the vicinity of Rocky Forks and the upper reaches of the watershed. Engelmann spruce-subalpine fir forest is confined to the higher slopes and

valleys and is fairly open and dry on the south and west-facing valley slopes. The area receives moderate winter snow accumulation and is generally warmer and drier than the Main Ranges to the west. Open grassy slopes and alpine meadows are common, especially along the east side of the drainage and in the vicinity of Cairn Pass. There is an extensive shrubby burn along the headwaters of the Rocky River.

This watershed is undeveloped. The Yellowhead highway crosses the Rocky River near its confluence with the Athabasca River; otherwise all access to the area is by foor or horseback.

Wildlife

All species of ungulates which occur in Jasper, except caribou, are found in the Rocky watershed. Caribou were hunted around the turn of the century by outfits out of Mountain Park (A. Burnstrom, pers. comm.) and may have occupied parts of this watershed at that time.

This is one of the most important watersheds in Jasper for sheep, which occur on all the mountains of the drainage. They are most abundant along the east side of the Rocky and Medicine Tent Rivers and between the Rocky and Restless Rivers. Small groups winter in the latter location and near Alpland Pass. The Miette Range and the open slopes above the Medicine Tent are major winter ranges. The upper Restless and Rocky Rivers are primarily summer ranges.

Elk are confined mainly to the Medicine tent and lower Rocky River valleys and are present all year round. A severe winter in 1974/75 caused a major die-off of elk from which they are still recovering (D. Martin, pers. comm.). Moose are found throughout the watershed and are commonest in the lower Rocky River valley. A large burn at the head of the Rocky is used as a winter range by moose.

Goats are ubiquitous but scarce. Most observations are on the Jacques Range. A dry soil lick between Makwa and Merlin ridges is used by goats.

Wolves frequent the Rocky valley at all seasons and probably den there. A meadow near Rocky Forks cabin is used as a summer rendezvous site. Black bears are not common, being confined mainly to the area downstream from Rocky Forks, but the entire watershed is highly important to grizzly bears (Russell et al. 1979).

Willow ptarmigan are near the southern limit of their distribution in this watershed, having been recorded at Alpland, Cairn and Blow Passes. Boreal owls are fairly common in the vicinity of Rocky Forks and Jacques Lake.

Management

The extent and undeveloped nature of this watershed render it highly valuable to the numerous species of wildlife that occur here. The healthy status of its bighorn sheep, grizzly and wolf populations indicate its ecological integrity and should be maintained by preserving the watershed in its wilderness state.

FIDDLE RIVER WATERSHED

The Fiddle River drains the Miette and Nikanassin Ranges in eastern Jasper National Park (Figure 1.2). Lying in the eastern part of the Front Ranges, it is a drier, windier area than most other parts of the park. The valleys are steep and rocky, covered with lodgepole pine forest on the lower slopes and dry lodgepole pine-spruce and Engelmann spruce-subalpine fir stands higher up. There are many high grassy slopes and ridgetops along the Nikanassin Range. Engelmann spruce-subalpine fir/willow/hairy wild rye (O18)forest predominates on alluvial fans and floodplains.

A scenic drive from Pocahontas leads to the developed hot spring pool at Sulphur Creek with its associated motel and campground. The rest of the watershed is undeveloped.

Wildlife

The Fiddle River watershed is important to all the species of ungulates that occur in Jasper with the exceptions of white-tailed deer and Woodland caribou. Bighorn sheep occur in all the mountains of this watershed and winter along the Nikanassin Range and Ashlar Ridge. Goats are less common but equally widespread. There is a major mineral lick associated with the Miette Hot Springs.

Elk occur throughout the watershed in summer and winter on Mount Drinnan and along the lower Fiddle River. Moose are widespread but uncommon. Cow moose with young calves have been recorded along Poacher's and Bryant Creeks. Following the unsuccessful wood bison introduction in 1978, two bison found their way into the Fiddle drainage and spent the summer of 1979 in the vicinity of Utopia Lake.

Wolves travel through the Fiddle River valley and have been recorded in Whitehorse Pass in mid-winter (warden records), but there is no evidence that this small watershed supports a resident population. The highest density of martens (60.71 tracks/10km-days) was recorded in this watershed but this is mostly an artifact of the small sample size. Other carnivores recorded on the 8.4 km-day of winter tracking in this drainage were Coyote and Short-tailed weasel (10 tracks each).

Management

The high importance of this watershed to ungulates is partly due to its undeveloped state. The Nikanassin Range, however, is a popular sheep hunting area and poaching will become an increasing problem as mineral exploration and logging roads improve access into this range from the east. Development of a new provincial recreation area by the Alberta government may also increase the recreational pressure on this watershed.

SNAKE INDIAN RIVER WATERSHED

The Snake Indian River drains most of the northern third of Jasper National Park. It rises in the glaciers and snowfields of the Main Ranges and flows east and then south to join the lower Athabasca River near the east entrance to the park. Major tributaries include Blue Creek, Deer Creek, Willow Creek, Strange Creek and the South Fork (Figure 1.2).

Engelmann spruce-subalpine fir and lodgepole pine-spruce forests predominate in the upper and middle Snake Indian River and Blue Creek valleys, with extensive alpine and upper subalpine meadows in the higher basins. Along Blue Creek there are stands of lodgepole pine-spruce forest with a unique open understory dominated by *Cladina, Peltigera* and other lichens.

Along lower Deer and Willow Creeks there is a mosaic of grassland, bog, lodgepole pine forest and aspen forest which is described in detail by Carbyn (1972a). Here the lower subalpine begins to give way to the montane ecoregion and winter snow accumulation averages shallow enough to allow deer and elk to winter in the area. There are large tracts of blown-down forest that have been curing since 1972 and now pose a substantial fire risk. A major fire in the Snake Indian valley would remove large dense stands of lodgepole pine and create more range for elk, moose and deer.

The lower Snake Indian River flows through an incised canyon, with lodgepole pine/poplar forest alternating with black spruce/willow bogs along the valley.

Park horses were wintered in the Willow Creek area until the early '70's. During this time a road was maintained from Devona to Willow Creek for hauling feed and supplies. This road is now maintained, for fire control and access by park staff, only as far as Seldom Inn. Nine warden patrol cabins are the only other human development in the watershed. Recreational use is limited to the trail network; the north boundary trail traverses this watershed and horse parties and backpackers use the Deer and Blue Creek valleys for access into the Willmore Wilderness.

Wildlife

Blue Creek valley is one of the most important caribou ranges in Banff and Jasper. Up to 61 Woodland caribou have been recorded here at once (Nov. 1957 - Jasper warden cards) and the area is used at all times of year. Caribou calve in Azure Pass, along the Ancient Wall, in the basins west of Blue Creek, and in Snake Indian Pass. Caribou from this population range into the Willmore, Deer Creek, Rock Creek and the middle and upper Snake Indian River. It is believed that they may move in winter east to the Berland River valley (M. Bloomfield, Alta. Fish and Wildlife, pers. comm.).

The Ancient Wall, between Deer and Blue Creeks, is one of the most important mountain goat ranges in Banff and Jasper. As many as 129 goats have been observed here (1960, Jasper warden cards). Goats winter on Mt. Kelsey and McLaren Pass. Goats also occur in large numbers in the northern part of the Bosche Range and in lower densities in all other mountains of the Snake Indian drainage.

The upper Snake Indian River supports very few ungulates compared to the lower parts of the watershed in the drier, more open Front Ranges. Up to 300 elk formerly wintered in the Willow/Deer Creek area but severe winters in the early 1970's depleted the population and at present fewer than 150 remain in the area in winter. There are only two historical occurences of elk upstream from the confluence of Blue Creek and the Snake Indian River in winter, both being solitary bulls in the Blue Creek meadows.

Mule deer are widespread in summer but winter mostly in the Willow Creek area and along the lower Snake Indian River valley. Sheep occupy the Bosche and DeSmet Ranges and the Ancient Wall.

Moose occur throughout the Snake Indian watershed. Known areas of winter concentrations include the shrubby meadows along upper Blue Creek, the Snake Indian Lakes area, and the vicinity of Willow, Mud and lower Deer Creeks.

An attempt to re-introduce wood bison to the Snake Indian valley was made by Canadian Wildlife Service and Parks Canada in 1978. Skeletal remains and old reports indicate that bison occupied the area until the early 1800's when they died out for unknown reasons. The reintroduced bison left their original location near Willow Creek and summered in the upper subalpine and alpine terrain along upper Deer Creek. Most ultimately left the park and travelled through the Willmore and the provincial forest reserve to near Grande Prairie (Davidson and Norcross 1978). The reintroduction attempt was considered a failure and there are no plans to try again in the immediate future.

The Willow Creek area is an important wolf denning, rendezvous and hunting area. Wolves travel through all parts of the Snake Indian drainage and are of special interest here since they occupy a large, relatively-undisturbed area with a diverse and abundant prey base. Carbyn (1972b, 1974b) has studied wolves and their prey/habitat relationships in this area.

Cougars occurred as far north and west as the Ancient Wall as recently as October 1971 (Jasper warden cards) but are now rare and largely confined the lower Snake Indian River valley.

Alberta's first and northern-most record of a House Finch was a specimen collected near Azure Lake in 1944 (Salt & Salt 1976). Golden Eagles nest on the Ancient

Wall and may nest in the DeSmet and Boule Ranges. Willow and white-tailed ptarmigan occur in the middle and upper Snake Indian River drainages and winter in the open shrub meadows along Blue Creek and the Snake Indian. There are beaver colonies along Blue Creek; the Snake Indian Lakes; Mud and Willow Creeks; and locally along the middle Snake Indian River.

MANAGEMENT CONSIDERATIONS

The presence of so large and diverse an area in a wilderness state ensures the maintenance of a complete and normally-functioning ecosystem in the northern part of Jasper. The presence of such sensitive indicators as wolves, caribou and grizzly in substantial numbers reflect the integrity of this wilderness ecosystem. Exclusion of any further development and of improved access will ensure that this area remains as rich and diverse in wildlife as it is at present.

The Snake Indian valley below Blue Creek supports fewer wintering elk and deer now than formerly. This can partly be attributed to the absence of fire as much of the valley is covered with dense, unproductive lodgepole pine forest. A *laissez-faire* fire policy in this area would allow greater habitat diversity and productivity for these ungulates as well as ensure that fire control does not lead to creation of better access and more disturbance.

Fire protection upstream from Blue Creek along both Blue Creek and the Snake Indian may be important, however, in maintaining the old-growth forest and lichen ground cover that are critical to caribou in this area.

The Blue Creek valley is a particularly important ungulate range, supporting substantial populations of caribou, goats, moose and sheep. Its protection from further disturbance and increased recreational use may well be critical to the maintenance of the caribou population of northern Jasper.

ROCK CREEK WATERSHED

Rock Creek and its major tributary, Mowitch Creek, drain from the northeast corner of Jasper into Rock Lake - just east of the park - and thence into the Wildhay River (Figure 1.2). Another creek that rises in Jasper National Park, Willow Creek - also drains into Rock lake but is discussed above in the account of the Snake Indian watershed.

The Rock Creek watershed is relatively dry, occurring in the Front Ranges where precipitation is lower and winds higher than farther west. There are extensive grassy alpine and upper subalpine meadows on the Starlight and Persimmon Ranges. Engelmann spruce-subalpine fir forest is confined mostly to upper subalpine slopes with east or north exposures, with lodgepole pine-spruce predominating over most of the watershed. There are extensive open shrub meadows along the floodplains of Rock and Mowitch Creeks.

Human use of this watershed is limited to horseback and backpacking parties that use the trails over Glacier Pass and up Rock Creek for access to the Willmore Wilderness. The nearest road access is at Rock Lake, three kilometers from the park boundary. A road which formerly gave access to upper Rock Creek through the Persimmon Range is now closed to motor vehicles and is used mainly in autumn by hunting outfits. There are two warden cabins in this watershed, at Little Heaven and Vega.

Wildlife

The Persimmon Range is one of the most important goat ranges in Banff and Jasper. Up to 60 were seen at one time in July 1980 (inventory files). This population ranges outside the park and is subject to permit hunting on provincial lands. It winters mostly on the south side of Daybreak Peak and along Rock Creek canyon. Goats occur

in lesser numbers on the Starlight Range but are common in the mountains between Mowitch Creek and the Deer Creek drainage.

Caribou occur in summer along the Starlight Range and in the vicinity of Glacier Pass, where they probably calf. In winter they have been recorded near Little Heaven and Vega but are not common.

Moose winter in the Mowitch and Rock Creek meadows and range throughout the watershed. Although there are several records of bull elk wintering in these meadows in the past (warden cards) there have been none since the early 1970's when elk populations declined due to severe winters.

Bighorn sheep occur year-round near Glacier Pass and on the Persimmon Range but wander to other parts of this watershed only during the summer. Mule deer winter along the lower slopes of the Persimmon Range.

Wolves range throughout the watershed and have been observed at rendezvous sites in the Little Heaven meadows. There have been no records of cougars in this drainage since 1958. There are active beaver colonies along both Mowitch and Rock Creeks.

Management

The Persimmon Range and adjacent slopes above Rock Creek provide valuable winter range for a variety of ungulates, particularly goats. Development of and increased access to this area would be detrimental to these ungulate populations. Similarly, the Glacier Pass area should be protected from increased use because of its importance to caribou and sheep.

SNARING RIVER WATERSHED

The Snaring River is a major tributary of the lower Athabasca River. It drains the Victoria Cross and DeSmet Ranges in northern Jasper (Figure 1.2). Its valley is narrow and heavily forested with Engelmann spruce-subalpine fir and lodgepole pine-spruce forest and it has few open alluvial meadows or extensive alpine areas.

The headwaters of the Snaring River are along the Continental Divide. Here there are open Engelmann spruce-subalpine fir forests interspersed with lush herb and willow meadows. The entire drainage receives heavy winter snow accumulation and is generally steep, moist, and heavily forested.

Upstream from the edge of the lower Athabasca River there is very little human use and no development. The only hiking trails are at the headwaters where they provide access to the Moose River valley of Mt. Robson Provincial Park. There is one warden patrol cabin, near Miette Pass.

The alluvial fan where the Snaring River joins the lower Athabasca River is transected by a service road and supports a public campground and a large gravel quarry.

The Snaring River valley was trapped and hunted in the early days of this century but has had no other recorded human use.

Wildlife

Ungulate populations are generally low along the Snaring River due to its isolation from winter ranges, paucity of good forage, and heavy winter snow accumulation. Caribou occur in the vicinity of the headwaters and formerly wintered throughout much of this watershed (Stelfox 1978) but have not been recorded there since the early 1970's (A. Burstrom, Jasper warden service, pers. comm.). Goats frequent all the mountains of

the watershed. Sheep are present on the De Smet Range and, in summer, on Mount Zenger.

Elk and mule deer are scarce in this watershed and do not occur here in winter. Moose are scarce but widespread.

Wolverine occur regularly at least in the headwaters region, but wolves range into this watershed only sporadically.

The moist, open upper subalpine forests of the headwaters region support Willow Ptarmigan, American porcupine and were the site of at least 2 singing Gray-cheeked Thrushes in 1980 (inventory files).

Management

Increased recreational use of the Snaring River headwaters could potentially disturb caribou, wolverine and other wildlife as well as cause damage to the moist meadow vegetation. The possibility that Gray-cheeked Thrushes may breed in this area should be more thoroughly investigated as this, and the Amethyst Lakes, are the only known locations in the southern Rocky Mountains where this species occurs during the breeding season.

SMOKY RIVER WATERSHED

The Smoky River drains the northern end of Jasper National Park, rising in the glaciers of the Main Ranges and flowing through Willmore Wilderness and Grande Cache to join the Peace River north of Grande Prairie. Its major park tributaries are Short and Twintree Creeks (Figure 1.2).

Although the higher valleys are typical subalpine Main Range valleys with steep slopes of Engelmann spruce-subalpine fir forest giving way to alpine basins and ridges at higher elevations and sedgy wetlands on the floodplains, the broad lower valley of the Smoky River is drier with extensive lodgepole pine forests. Snowfall is generally too high to allow most ungulates to winter in the valley.

There has been no development of the Smoky River valley in the park and access from the Alberta side is restricted by the Willmore. Logging roads in the Holmes River drainage of B.C. allow vehicle access to within 5 km of the park boundary at Bess and Carcajou Passes. Warden patrol cabins at Twintree Lake, Smoky River, Wolverine and Adolphus Meadows are used intermittently by park staff. Berg Lake, in Mount Robson Provincial Park, B.C., is a popular backpacking area and also supports an outfitter cabin camp; the Adolphus meadows are easily reached by a half hour walk through Robson Pass from here.

There is little documented history of human or wildlife use of the Smoky River watershed. The area was trapped and hunted in the 1800's and early 1900's, but it has never been used extensively by humans.

Wildlife

Very few ungulates and little ungulate sign were observed in this watershed during the inventory. Sheep may occasionally wander in summer into the alpine areas northeast of Twintree Creek from established ranges along Hardscrabble and Blue Creeks, but they are not known to winter in this drainage. Goats are present in low numbers throughout the watershed. Caribou with calves were observed in Bess, Carcajou and Snake Indian Passes. The Twintree Creek area is used by caribou in winter (warden records). Moose range at all seasons throughout the Smoky River watershed, concentrating in autumn and winter along the main valley from Adolphus to the boundary, in alluvial meadows and on avalanche slopes. Deer and elk are rare.

There is a seepage lick in Byng Pass which is used by moose and caribou.

Wolves from the lower Smoky and from the Snake Indian River both range into this watershed. There are several old warden records from Twintree Lakes and Snake Indian Pass, at all seasons, of packs ranging in size up to 12, and one unverified record of 24 wolves at Twintree Lake.

There are few records of coyotes or cougar. Lynx habitat is abundant in the lower subalpine part of the watershed where fires earlier in the century have created extensive dense young lodgepole pine forests. There are several beaver colonies in the valley bottom downstream from Chown Creek. Porcupines are more abundant in the Smoky River drainage than anywhere else in Banff and Jasper, with concentrations noted in Snake Indian Pass, at Wolverine cabin, and at Smoky cabin. During winter this species is the only readily-available medium-sized prey species in the area and its abundance may in part account for the ubiquity of wolverines and the presence of fisher, a species which is extremely rare in Banff and Jasper.

Richarson's water voles have been recorded in Moose Pass, this being the second most northerly record of this species in Alberta (Salt 1978). Another exceptional record is of a singing Rock Wren in Snake Indian Pass in 1980 (inventory records); this is also the northern-most record of this species (Salt and Salt 1976).

Management

This watershed is of low importance to ungulates except to Woodland caribou which calve here. Increased access to Bess and Carcajou Passes from the west may lead to disturbance of nursery groups. Closure of B.C. Forest service roads following logging should be encouraged.

The exceptional abundance of porcupines is of scientific interest, particularly in light of this species' importance as prey for large mustelids. Every effort should be made to ensure that porcupines are not killed unnecessarily around patrol cabins.

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